Hornsea Project Four: Environmental Statement (ES)

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Volume A5, Annex 7.1: Navigational Risk Assessment (Part 2)

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16 Adverse Weather Impacts on Routeing

303. Given the prominence of commercial ferries operated by DFDS Seaways within the vessel traffic survey data assessed for the Hornsea Four array area, additional consultation and assessment has been undertaken with commercial ferry operators including DFDS Seaways and Sea-Cargo to ensure that their regular routeing was considered fully, including the identification of commercial ferries within the Hornsea Four array area shipping and navigation study area (see Section 15.1.6). This section focuses on adverse weather routeing given the implications if a vessel is unable to make passage in adverse weather due to the presence of the development.

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

305. The following subsections consider the adverse weather routes (where present) for each of the commercial ferry routes identified within and in proximity to the Hornsea Four array area. A baseline with a wider context than the main vessel traffic survey has been established for each route using 12 months of AIS recorded between September 2018 and August 2019 by satellite. The use of satellite based AIS data ensures reasonable coverage at a wider extent with less range related constraints than are associated with use of site-specific or shore-based data.

306. Any transits characteristic of adverse weather routeing have been verified using weather data in the region from the Met Office. Additionally, as part of the consultation undertaken with commercial ferry operators, some passage plans have been provided to assist informing the baseline and have also been included.

16.1 Immingham to Esbjerg (DFDS Seaways)

307. Figure 16.1 presents a plot of AIS data for DFDS Seaways operated vessels routeing between Immingham and Esbjerg. Figure 16.1 also includes normal and adverse weather routes based upon waypoint information for the *Ark Germania* provided by DFDS Seaways during consultation. It is noted that the normal weather routeing (both the AIS data and waypoint information provided by DFDS Seaways) does not account for the presence of Hornsea Project Two (consented at the time of consultation and now under construction).

308. Five DFDS Seaways operated vessels (commercial Ro Ro ferries) were identified on the Immingham to Esbjerg route (Route 3 in Figure 15.16) with a total of between one and two transits per day.

309. For four of the five vessels, – the *Ark Dania*, *Ark Germania*, *Britannia Seaways* and *Jutlandia Seaways* – all normal weather transits passed south of the Hornsea Four array area and north of Hornsea Project One. From the vessel traffic survey data (see Section 15.1.6), it is known that normal weather transits also pass north of the now under construction Hornsea Project Two. The other vessel – the *Fionia Seaways* – primarily made normal weather transits south of Hornsea Project One, and thus not in proximity to the Hornsea Four array area.

310. Adverse weather routeing was identified for those vessels which normally used the route passing north of Hornsea Project One (and Hornsea Project Two). In proximity to Hornsea Four the adverse weather routeing was largely aligned with the normal route used by the *Fionia Seaways*. Considering all transits between Immingham and Esbjerg by DFDS Seaways operated vessels, approximately 4% followed an adverse weather route.

311. Given that the passing distance from the Hornsea Four array area is increased on the adverse weather route, it is anticipated that this route will not be impacted by the presence of Hornsea Four.

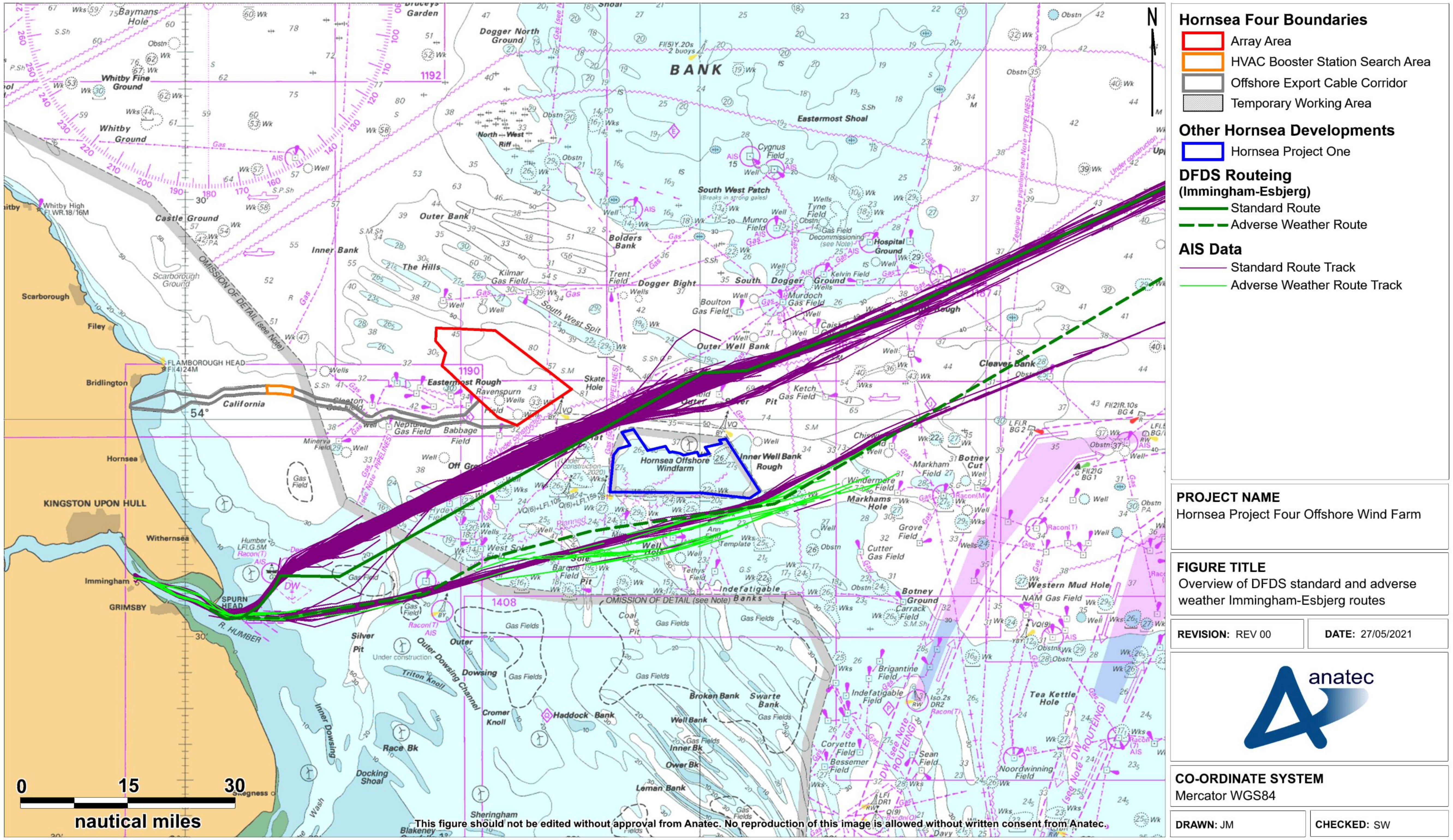


Figure 16.1 Overview of DFDS Seaways standard and adverse weather routeing between Immingham and Esbjerg

16.2 Immingham to Gothenburg (DFDS Seaways)

312. Figure 16.2 presents a plot of AIS data for DFDS Seaways operated vessels routeing between Immingham and Gothenburg. Figure 16.2 also includes normal and adverse weather routes based upon information provided by DFDS Seaways during consultation. It is noted that the southern adverse weather route provided by DFDS Seaways does not account for the presence of Hornsea Project One (under construction at the time of consultation and now operational) or Hornsea Project Two (consented at the time of consultation and now under construction).

313. Six DFDS Seaways operated vessels (commercial Ro Ro ferries) were identified on the Immingham to Gothenburg route (Route 1 in Figure 15.16) with a total of between one and two transits per day.

314. For all six vessels – the *Ficaria Seaways*, *Magnolia Seaways*, *Petunia Seaways*, *Begonia Seaways*, *Primula Seaways* and *Freesia Seaways* – all normal weather transits passed south of the Hornsea Four array area and north of Hornsea Project One.

315. Adverse weather routeing was identified for four of the six vessels and involved two distinct alternatives. The first of these alternatives involved passing in a north-south direction to the west of the Hornsea Four array area and north around the Dogger Bank. Considering all transits between Immingham and Gothenburg by DFDS Seaways operated vessels, approximately 1% followed this adverse weather route. Given that this adverse weather route does not pass through or in close proximity to the Hornsea Four array area, it is anticipated that this route will not be impacted by the presence of Hornsea Four.

316. The second adverse weather alternative involved passing further south but still north of Hornsea Project One, on a route coinciding with DFDS Seaways' normal weather route between Immingham and Esbjerg (see Section 16.1). Considering all transits between Immingham and Gothenburg by DFDS Seaways operated vessels, approximately 4% followed this adverse weather route. With the Hornsea developments in place, this route could utilise the gap between Hornsea Four and Hornsea Project Two, noting the increased flexibility the gap offers for vessel movements compared to a navigational corridor. However, an alternative routeing option exists, with vessels on this route able to shift south of the Hornsea developments, noting that this would place them on a similar passage to the already in use adverse weather route between Immingham and Esbjerg, i.e. a route known to be considered safe for DFDS Seaways vessels operating in adverse weather. Therefore, although this adverse weather route may be impacted by Hornsea Four, there is a safe and reasonable alternative. Moreover, with the low frequency of use, the impact upon the route is not considered to be substantial.

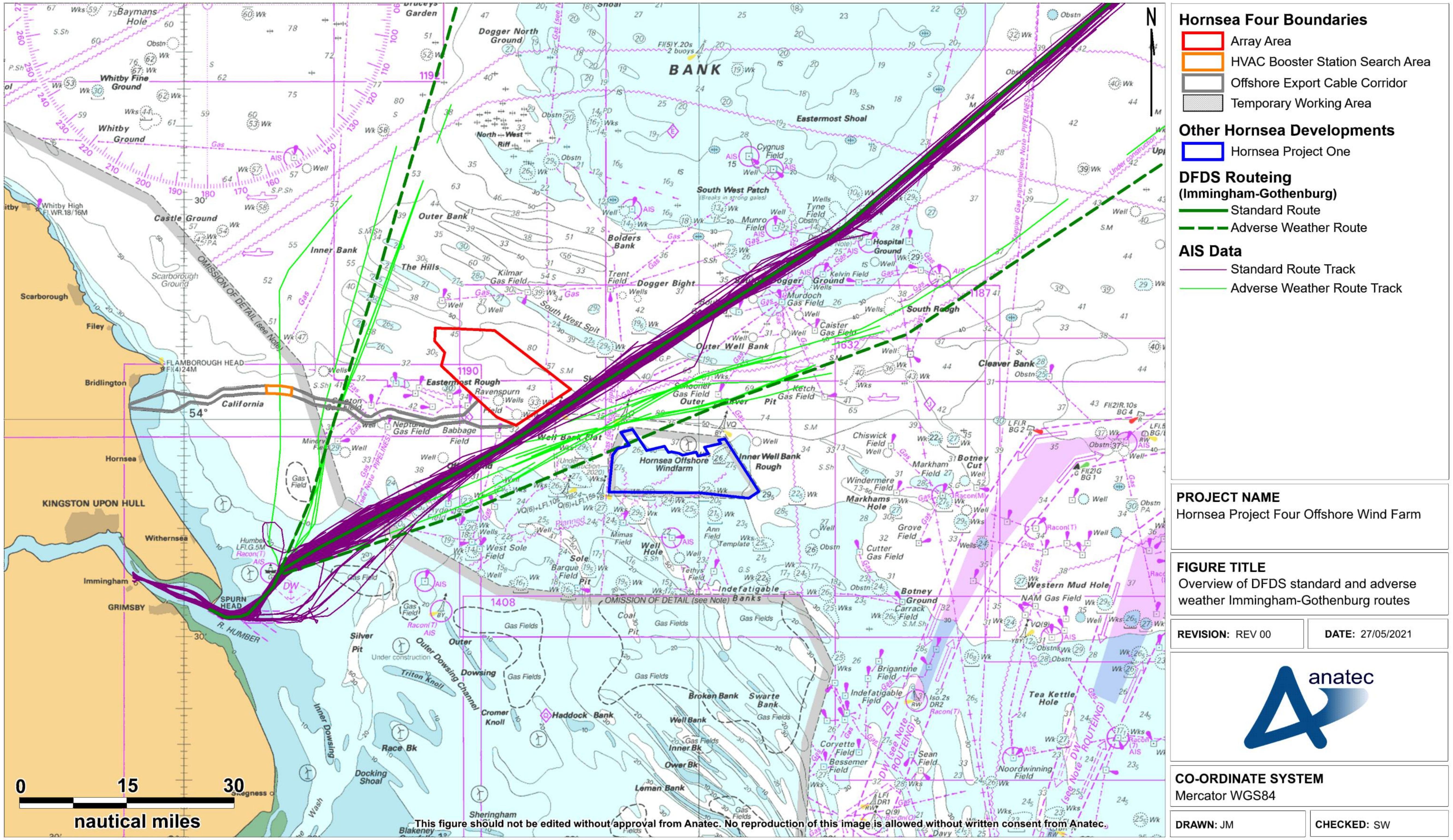


Figure 16.2 Overview of DFDS Seaways standard and adverse weather routeing between Immingham and Gothenburg

16.3 North Shields to Ijmuiden (DFDS Seaways)

317. Figure 16.3 presents a plot of AIS data for DFDS Seaways operated vessels routeing between North Shields and Ijmuiden. Figure 16.3 also includes normal and adverse weather routes based upon information provided by DFDS Seaways during consultation. Additionally, given that this route has shifted following the commencement of Hornsea Project Two construction, the associated vessel tracks from the vessel traffic surveys (see Section 15.1.6) have been included for context.

318. Two DFDS Seaways operated vessels (passenger Ro Ro ferries) were identified on the North Shields to Ijmuiden route with a total of between one and two transits per day. It is noted that each vessel was in dry dock for separate periods between January and March 2019, resulting in the number of transits being lower than is typical of the route. It can therefore be expected that there would typically be two transits per day across both vessels on this route, as was the case during the periods of the vessel traffic surveys.

319. For both vessels – the *King Seaways* and *Princess Seaways* – the majority of normal weather transits prior to the construction of Hornsea Project Two (2018/19 data) passed along the western boundary of the Hornsea Four array area. Following the commencement of Hornsea Project Two construction (2020/21 vessel traffic survey data), normal weather transits pass between platforms in the Ravenspurn gas field, increasing the passing distance from the Hornsea Four array area.

320. Adverse weather routeing was identified for both vessels in the extensive 2018/19 data and involved one of two routes closer to the UK east coast, with a significantly greater distance from the Hornsea Four array area. Considering all transits between North Shields and Ijmuiden by DFDS Seaways operated vessels, approximately 5% followed this adverse weather route. It is therefore anticipated that the routes will not be impacted by the presence of the Hornsea Four array area.

321. Although the adverse weather routes do pass in proximity to the Hornsea Four HVAC booster station search area (as illustrated within the vessel traffic survey data for the Hornsea Four HVAC booster station search area in Section 15.3.6), no change in passage is necessary. Therefore, it is anticipated that the routes will not be impacted by the presence of the Hornsea Four HVAC booster stations.

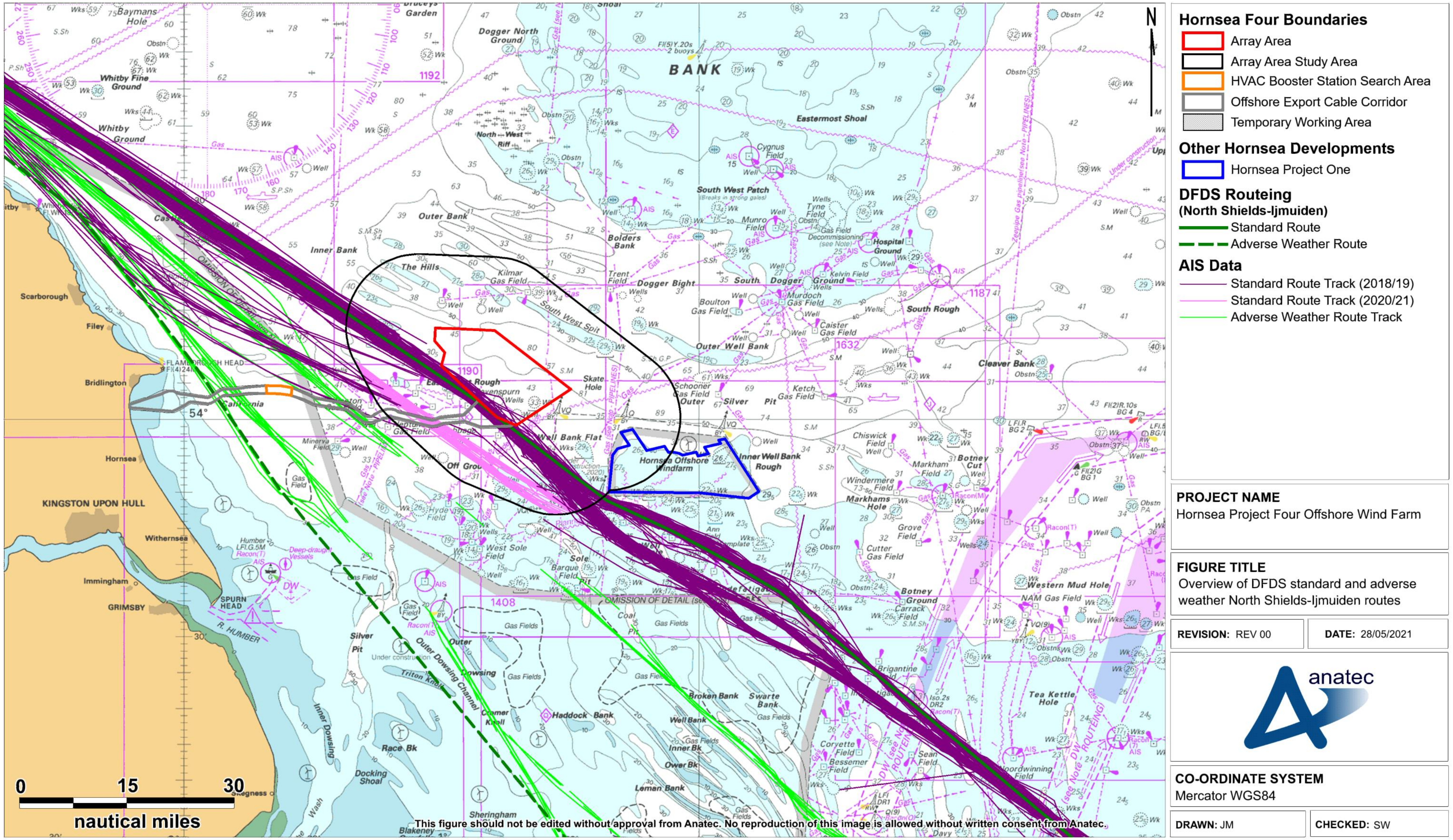


Figure 16.3 Overview of DFDS Seaways standard and adverse weather routeing between North Shields and Ijmuiden

16.4 Other Routes

322. Other routes used by commercial ferries were also identified from the vessel traffic survey data, but were used too infrequently to identify any adverse weather transits. Given the infrequent nature of these routes, it can be assumed that the number of adverse weather transits undertaken by vessels on these routes is very low (noting that, even for the more frequently used routes assessed in the previous subsections, the ratio of adverse weather to normal routeing was low).

323. For completeness, the infrequent routes for which no adverse weather transits could be identified are outlined in Table 16.1 and includes vessels identified both during the 2020/21 and 2018/19 vessel traffic surveys.

Table 16.1 Commercial ferry routes with no adverse weather transits identified

Route	Operator	Vessel(s)
Immingham–Oslo (Norway)	DFDS Seaways	*Lysbris Seaways*
		Lysvik Seaways
		Finlandia Seaways
Immingham–Riga (Latvia)	DFDS Seaways	*Norrland*
Immingham–Tananger	Sea-Cargo	*SC Astrea*
		SC Ahtela
		SC Connector
		Bore Bay
Hull–Helsinki	Finnlines	*Finnmaster*
Tyne–Emden (Germany)	Euro Marine Carrier	*City of St. Petersburg*

17 Navigation, Communication and Position Fixing Equipment

324. This section discusses the potential impacts upon the communication and position fixing equipment of vessels that may arise due to the infrastructure associated with Hornsea Four. The screening of the hazards into the impact assessment is summarised in Table 7.17 of **Volume A2, Chapter 7: Shipping and Navigation**.

17.1 Very High Frequency Communications (Including Digital Selective Calling)

325. In 2004, trials were undertaken at the North Hoyle Offshore Wind Farm, located off the coast of North Wales. As part of these trials, tests were undertaken to evaluate the operational use of typical small vessel VHF transceivers (including Digital Selective Calling (DSC)) when operated close to WTGs.

326. The WTGs 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 WTGs, then it is reasonable to assume that larger vessels with higher powered and more efficient systems would also be unaffected.

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

328. Furthermore, as part of SAR trials carried out at the North Hoyle Offshore 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).

329. In addition to the North Hoyle trials, a desk-based study was undertaken for the Horns Rev 3 Offshore Wind Farm in Denmark in 2014 and it was concluded that there were not expected to be any conflicts between point-to-point radio communications networks and no interference upon VHF communications (Energinet.dk, 2014).

330. Following consideration of these reports, and noting that since the trials detailed above there have been no significant issues with regards to VHF observed or reported, Hornsea Four is anticipated to have no significant impact upon VHF communications.

17.2 Very High Frequency Direction Finding

331. During the North Hoyle Offshore Wind Farm trials in 2004, the VHF Direction Finding (DF) equipment carried in the trial boats did not function correctly when

very close to WTGs (within approximately 50 m). This is deemed to be a relatively small-scale impact due to the limited use of VHF DF equipment and will not impact operational or SAR activities (MCA and QinetiQ, 2004).

332. Throughout the 2005 SAR trials carried out at North Hoyle, 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 1 nm, the homer system operated as expected with no apparent degradation.

333. Since the trials detailed above, no significant issues with regards to VHF DF have been observed or reported, and therefore Hornsea Four is anticipated to have no significant impact upon VHF DF equipment.

17.3 Automatic Identification System

334. No significant issues with interference to AIS transmission from operational offshore wind farms has been observed or reported to date. Such interference was also not evident in the trials carried out at the North Hoyle Offshore Wind Farm (MCA and QinetiQ, 2004).

335. 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. However, given no issues have been reported to date at operational developments or during trials, no significant impact is anticipated due to Hornsea Four.

17.4 Navigational Telex Systems

336. 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 a screen, depending upon the model.

337. 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 user's location, other information options may be available such as ice warnings for high latitude sailing.

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

339. Although no specific trials have been undertaken, no significant effect on NAVTEX has been reported to date at operational developments, and therefore no significant impact is anticipated due to Hornsea Four.

17.5 Global Positioning System

340. Global Positioning System (GPS) is a satellite based navigational system. GPS trials were also undertaken throughout the 2004 trials at the North Hoyle Offshore Wind Farm and it was stated that "*no problems with basic GPS reception or positional accuracy were reported during the trials*".

341. 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).

342. Therefore, there are not expected to be any significant impacts associated with the use of GPS systems within or in proximity to the Hornsea Four array area, noting that there have been no reported issues relating to GPS within or in proximity to any operational offshore wind farms to date.

17.6 Electromagnetic Interference

343. 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.

344. 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 event of power loss or as a secondary source, it should not be allowed to be affected to the extent that safe navigation is prohibited. The important factors with respect to cables that affect the resultant deviation are:

- Water depth;
- Burial depth;
- Current (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.

345. Hornsea Four 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 (EMF) significant enough to impact marine magnetic

compasses (Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR), 2008).

346. No problems with respect to magnetic compasses have been reported to date in any of the trials carried out (inclusive of SAR helicopters) nor at any operational offshore wind farms. However, small vessels with simple magnetic steering and hand bearing compasses should be wary of using these close to WTGs as with any structure in which there is a large amount of ferrous material (MCA and QinetiQ, 2004). This will be considered as part of the Cable Specification and Installation Plan (see Section 7.8 of **Volume A2, Chapter 7: Shipping and Navigation**).

347. Electromagnetic interference in relation to the Viking Link Interconnector and vessels passing through the gap between Hornsea Four and Hornsea Project Two is considered in Section 19.3.8.

17.7 Marine Radar

348. This section summarises trials and studies undertaken in relation to Radar effects from offshore wind farms in the UK. It is important to note that since the time of the trials and studies discussed, WTG technology has advanced significantly, most notably in terms of the size of WTGs available to be installed and utilised. The use of these larger WTGs allows for a greater minimum spacing than was achievable at the time of the studies being undertaken, which is beneficial in terms of Radar interference effects (and surface navigation in general) as detailed below.

17.7.1 Trials

349. During the early years in offshore renewables within the UK, maritime regulators undertook a number of trials (both shore-based and vessel-based) into the effects of WTGs on the use and effectiveness of marine Radar.

350. In 2004 trials undertaken at the North Hoyle Offshore Wind Farm (MCA and QinetiQ, 2004) identified areas of concern regarding the potential impact on marine and shore-based Radar systems due to the large vertical extents of the WTGs (based on the technology at that time). This resulted in Radar responses strong enough to produce interfering side lobes and reflected echoes (often referred to as false targets or ghosts).

351. Side lobe patterns are produced by small amounts of energy from the transmitted pulses that are radiated outside of the narrow main beam. The effects of side lobes are most noticeable within targets at short range (below 1.5 nm) and with large objects. Side lobe echoes form either an arc on the Radar screen similar to range rings, or a series of echoes forming a broken arc, as illustrated in Figure 17.1.

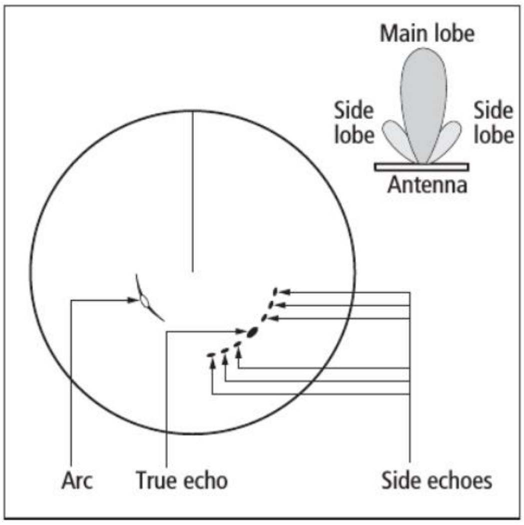


Figure 17.1 Illustration of side lobes on Radar screen

352. Multiple reflected echoes are returned from a real target by reflection from some object in the Radar beam. Indirect echoes or 'ghost' images have the appearance of true echoes but are usually intermittent or poorly defined; such echoes appear at a false bearing and false range, as illustrated in Figure 17.2.

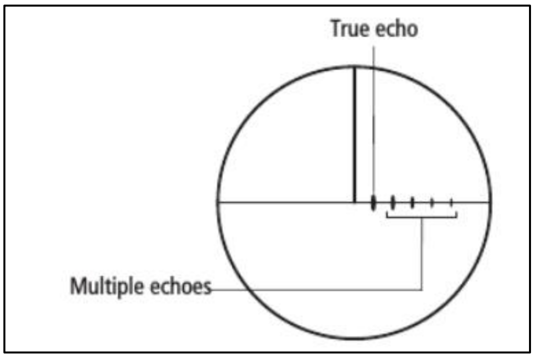


Figure 17.2 Illustration of multiple reflected echoes on Radar screen

353. Based upon the results of the North Hoyle trials, the MCA produced a Shipping Route Template designed to give guidance to mariners on the distances which should be established between shipping routes and offshore wind farms.

354. A second set of trials conducted at Kentish Flats Offshore Wind Farm in 2006 on behalf of the British Wind Energy Association (BWEA) – now RenewableUK (BWEA, 2007) – also found that Radar antennas which are sited unfavourably with respect to components of the vessel's structure can exacerbate effects such as side lobes and reflected echoes. Careful adjustment of Radar controls suppressed these spurious Radar returns but mariners were warned that there is a consequent 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 should be taken in making such adjustments.

355. Theoretical modelling of the effects of the development of the proposed Atlantic Array Offshore Wind Farm, which was to be located off the south coast of Wales in the UK, on marine Radar systems was undertaken by the Atlantic Array project (Atlantic Array, 2012) and considered a wider spacing of turbines than that considered within the early trials. The main outcomes of the modelling were the following:

- Multiple and indirect echoes were detected under all modelled parameters;
- The main effects noticed were stretching of targets in azimuth (horizontal) and appearance of ghost targets;
- There was a significant amount of clear space amongst the returns to ensure recognition of vessels moving amongst the WTGs and safe navigation;
- Even in the worst case with Radar operator settings artificially set to be poor, there is significant clear space around each WTG 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 was concluded that the amount of shadowing observed was very little (noting that the model considered lattice-type foundations which are sufficiently sparse to allow Radar energy to pass through);
- The lower the density of WTGs 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 Radar scanners;
- It is important for passing vessels to keep a reasonable separation distance between the WTGs in order to minimise the effect of multipath and other ambiguities;
- The Atlantic Array study undertaken in 2012 noted that the potential for Radar interference was mainly a problem during periods of reduced visibility when mariners may not be able to visually confirm the presence of other vessels in proximity (i.e. those without AIS installed which are usually fishing and recreational craft). It is noted that this situation would arise with or without WTGs in place; and
- There is potential for the performance of a vessel's ARPA to be affected when tracking targets in or near the array. Although greater vigilance is required, during the Kentish Flats trials it was shown that false targets were quickly identified as such by the mariners and then by the equipment itself.

356. In summary, experience in UK waters has shown that mariners have become increasingly aware of any Radar effects as more offshore wind farms become operational. Based on this experience, the mariner can interpret the effects correctly, noting that effects are the same as those experienced by mariners in other environments such as in close proximity to other vessels or structures. Effects can be effectively mitigated by 'careful adjustment of Radar controls'.

357. The MCA has also produced guidance to mariners operating in proximity to OREIs in the UK which highlights Radar issues amongst others to be taken into account when planning and undertaking voyages in proximity to OREIs (MCA, 2008). The interference buffers presented in Table 17.1 are based primarily on MGN 654 (MCA, 2021) but also consider the content of MGN 371 (MCA, 2008), MGN 543 (MCA, 2016) and MGN 372 (MCA, 2008).

Table 17.1 Distances at which impacts on marine Radar occur

Distance at Which Effect Occurs (nm)	Identified Effects (as per MGNs)
0.5	▪ Intolerable impacts can be experienced at under 0.5 nm. ▪ X-Band Radar interference is intolerable under 0.25 nm. ▪ Vessels may generate multiple echoes on shore-based Radars under 0.45 nm.
1.5	▪ Under MGN 654, impacts on Radar are considered to be tolerable with mitigation between 0.5 nm and 3.5 nm. ▪ S-band Radar interference starts at 1.5 nm. ▪ Echoes develop at approximately 1.5 nm, with progressive deterioration in the Radar display as the range closes. Where a main vessel route passes within this range considerable interference may be expected along a line of WTGs. ▪ The WTGs produced strong Radar echoes giving early warning of their presence. ▪ Target size of the WTG echo increases close to the WTG with a consequent degradation on both X and S-Band Radars.

358. As noted in Table 17.1, the onset range from the WTGs of false returns is approximately 1.5 nm, with progressive deterioration in the Radar display as the range closes. If interfering echoes develop, the requirements of the Convention on International Regulations for Preventing Collisions at Sea (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 Look-out* to take into account information from other sources which may include sound signals and VHF information, for example from a Vessel Traffic Service (VTS) or AIS (MCA, 2017).

17.7.2 Experience from Operational Developments

359. The evidence from mariners operating in proximity to existing offshore wind farms is that they quickly learn to adapt to any effects. Figure 17.3 presents the example of the Galloper and Greater Gabbard Offshore Wind Farms, which are located in

proximity to IMO routeing measures. Despite this proximity to heavily trafficked TSS lanes, there have been no reported incidents or issues raised by mariners who operate within the vicinity. The interference buffers presented in Figure 17.3 are as per Table 17.1.

360. As indicated by Figure 17.3, vessels utilising these TSS lanes will experience some Radar interference based on the available guidance. Both developments are operational, and each of the lanes is used by a minimum of five vessels per day on average. However, to date, there have been no incidents recorded (including any related to Radar use) or concerns raised by the users.

361. AIS information can also be used to verify the targets of larger vessels (generally vessels over 15 m LOA (the minimum threshold for fishing vessel AIS carriage requirements). It is noted that only approximately 2% of the vessel traffic recorded within the Hornsea Four array area shipping and navigation study area was under 15 m LOA, reflecting the distance offshore. For any smaller vessels, particularly fishing vessels and recreational vessels, AIS Class B devices are becoming increasingly popular and allow the position of these small craft to be verified when in proximity to an offshore wind farm.

17.7.3 Increased Target Returns

362. 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 upon its size, shape and aspect angle.

363. Larger WTGs (either in height or width) will return greater target sizes and/or stronger false targets. However, there is a limit to which the vertical beam width would be affected (20° to 25°) dependent upon the distance from the target. Therefore, increased WTG height in the array will not create any effects in addition to those already identified from existing operational wind farms (i.e., interfering side lobes, multiple and reflected echoes).

364. Again, when taking into consideration the potential options available to marine users (e.g. reducing gain to remove false returns) and feedback from operational experience, this shows that the effects of increased returns can be managed effectively.

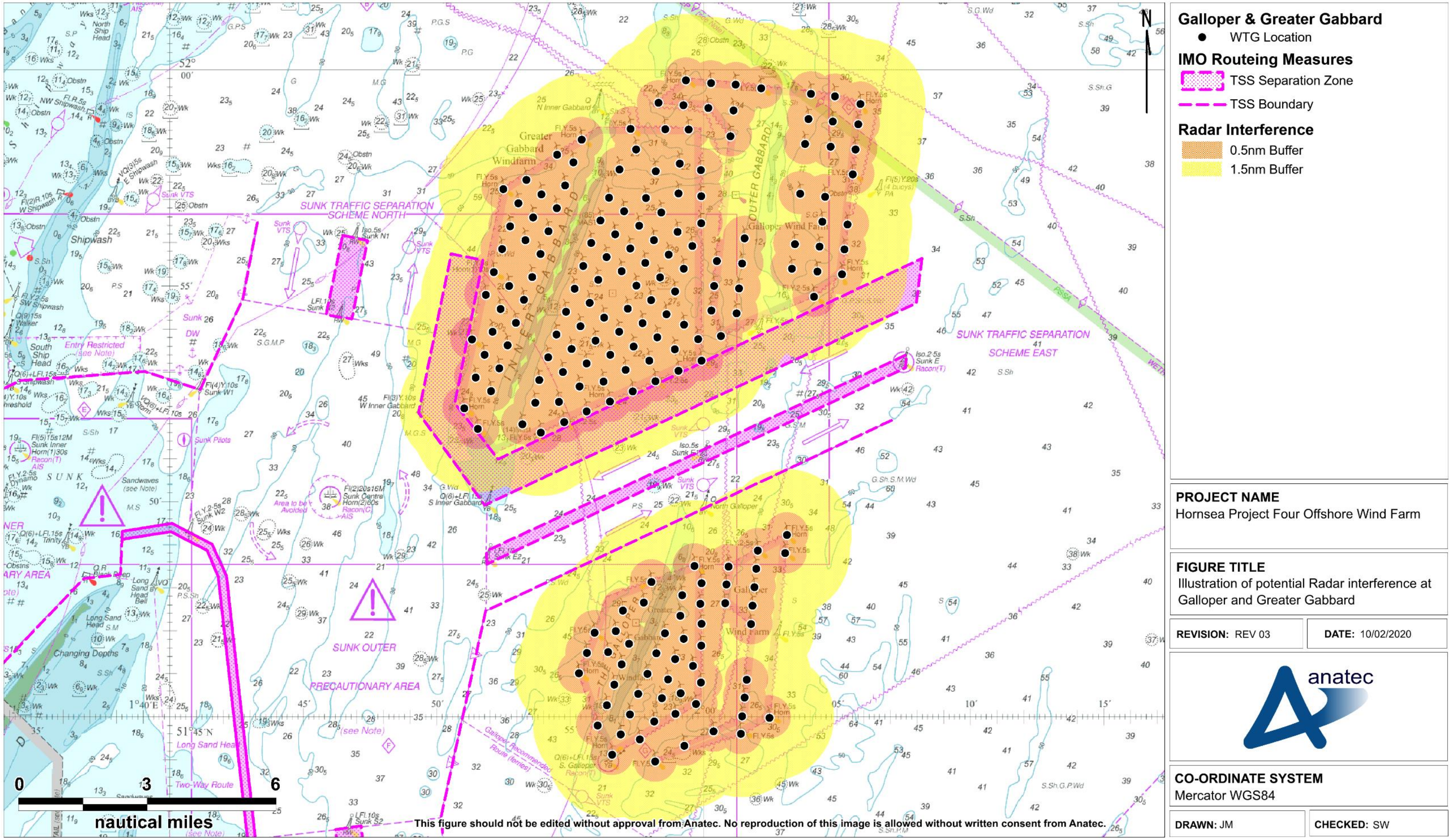


Figure 17.3 Illustration of potential Radar interference at Greater Gabbard and Galloper Offshore Wind Farms

17.7.4 Fixed Radar Antenna Use in Proximity to an Operational Wind Farm

365. It is noted that there are multiple operational wind farms including Galloper that successfully operate fixed Radar antenna from locations on the periphery of the array. These antennas are able to provide accurate and useful information to onshore coordination centres.

17.7.5 Application to Hornsea Four

366. Upon development of Hornsea Four, some commercial vessels may pass within 1.5 nm of the wind farm infrastructure and therefore may be subject to a minor level of Radar interference. Trials, modelling and experience from existing developments note that any impact can be mitigated by adjustment of Radar controls.

367. Figure 17.4 presents an illustration of potential Radar interference due to the Hornsea Four and Hornsea Project Two arrays relative to the post wind farm routeing illustrated in Section 20.5.2. The Radar effects have been applied to the indicative Hornsea Four layout introduced in Section 9.2.1 and the final Hornsea Project Two layout (which is now in the process of being installed).

368. Vessels passing within the array will be subject to a greater level of interference with impacts becoming more substantial in close proximity to WTGs. This will require additional mitigation by any vessels including consideration of the navigational conditions (i.e. visibility) when passage planning and compliance with the COLREGs will be essential. Again, looking at existing experience within UK offshore wind farms, vessels do navigate safely within arrays including those with spacing significantly less than at Hornsea Four.

369. For vessels transiting through the gap between Hornsea Four and Hornsea Project Two there may be a potential for increased exposure to Radar interference. However, taking account of the ‘bow tie’ shape of the gap, the duration of the transit for which the distance from WTGs will be less than 1.5 nm will be low (as noted in Section 19.3.2, the average duration of transits through the gap in full is anticipated to be 34 minutes) and the duration of transit for which the distance from WTG will be less than 0.5 nm will be very low. Mitigations are available to vessels as listed throughout this section (e.g. adjustment of Radar controls) and the impact is within parameters already safely managed at existing offshore wind farm developments. It is also noted that the likelihood of multiple vessels being in transit within the gap simultaneously is low and therefore there is likely to be an increased ability to distance from WTGs (see Section 19.3.3 for further analysis).

370. Overall, the impact on marine Radar is expected to be low and no further impact upon navigational safety is anticipated outside the parameters which can be mitigated by operational controls.

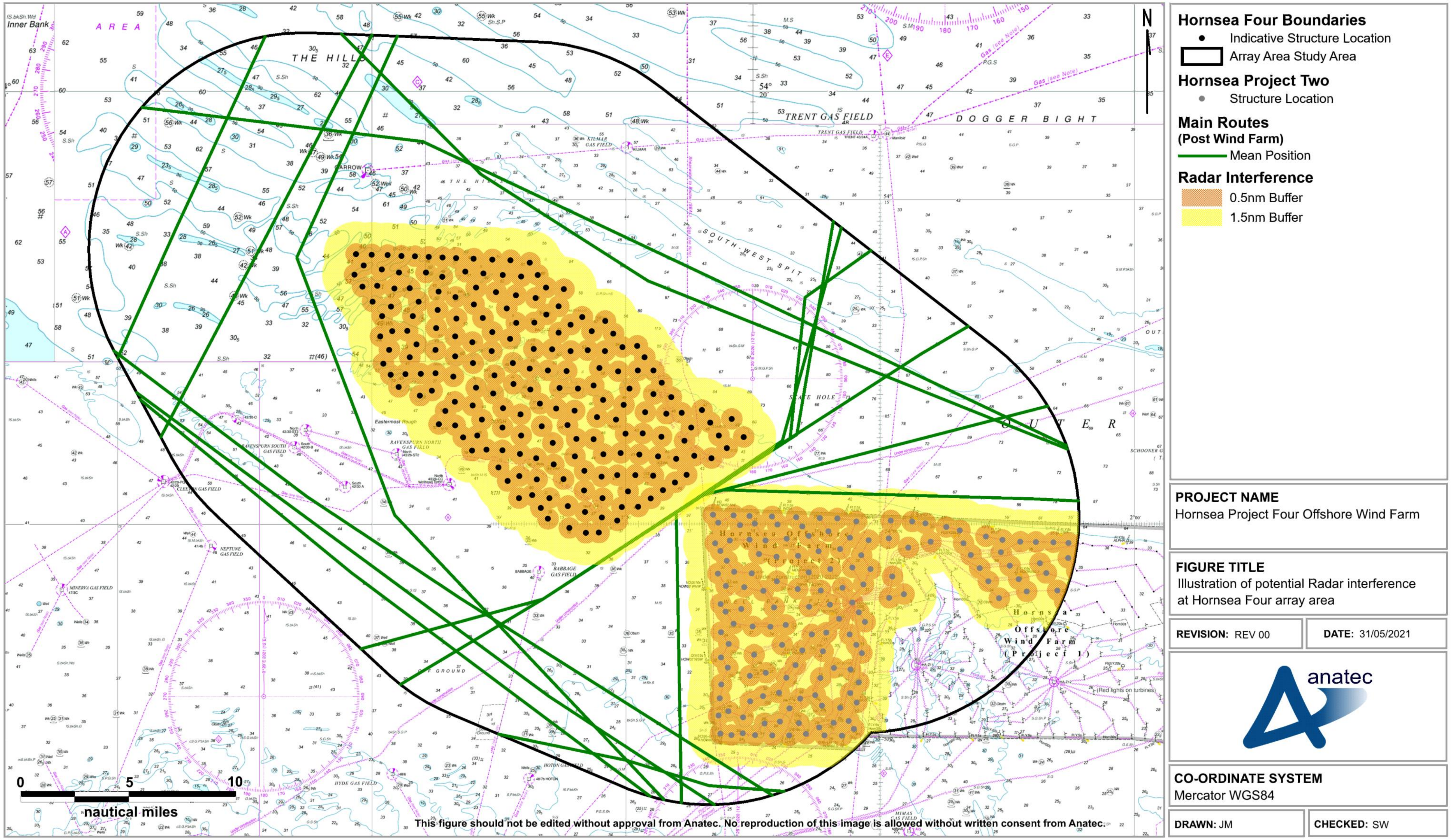


Figure 17.4 Illustration of potential Radar interference at Hornsea Four and Two array areas

17.8 Sound Navigation Ranging Systems

371. No evidence has been found to date with regard to existing offshore wind farms to suggest that Sound Navigation Ranging (SONAR) systems produce any kind of SONAR interference which is detrimental to the fishing industry, or to military systems. No impact is therefore anticipated in relation to Hornsea Four.

17.9 Noise

17.9.1 Surface Noise

372. The sound level from an offshore wind farm at a distance of 350 m has been predicted to be between 51 decibels (dB) and 54 dB (A). Furthermore, modelling undertaken during the consenting process for the Atlantic Array Offshore Wind Farm showed that the highest predicted level due to operational WTG noise (for a 125 m tall 8 Megawatt (MW) WTG) is around 60 dB (Atlantic Array, 2012).

373. A vessel's whistle for a vessel of 75 m length should generate in the order of 138 dB and be audible at a range of 1.5 nm (IMO, 1972/77); hence this should be heard above the background noise of the WTGs. Similarly, foghorns will also be audible over the background noise of the WTGs.

374. There are therefore no indications that the sound level of Hornsea Four will have a significant influence on marine safety.

17.9.2 Underwater Noise

375. In 2005, the underwater noise produced by WTGs of 110 m height and with 2 MW capacity was measured at the Horns Rev Offshore Wind Farm in Denmark. The maximum noise levels recorded underwater at a distance of 100 m from the WTGs was 122 dB or 1 micropascal (µPa) (Institut für technische und angewandte Physik (ITAP), 2006).

376. During the operation and maintenance phase of Hornsea Four, the subsea noise levels generated by WTGs will likely be greater than that produced at Horns Rev given the larger WTG size, but nevertheless is not anticipated to have any significant impact as they are designed to work in pre-existing noisy environments. Operational subsea noise is considered in more detail in **Volume A4, Annex 4.5: Subsea Noise Technical Report**.

17.10 Existing Aids to Navigation

377. The only buoys within the Hornsea Four array area shipping and navigation study area at the time of writing are a selection of construction buoys for Hornsea Project Two located south east of the Hornsea Four array area. As noted in Section 10.3, these marks will be removed following the commissioning of the development and there is not expected to be any overlap between Hornsea Project Two construction and the operation of Hornsea Four.

378. Therefore, there is anticipated to be no associated impact on existing aids to navigation, with the array itself forming an aid to navigation given its lighting and marking.

18 Hazard Workshop Overview

379. A key element of the Hornsea Four consultation phase was the Hazard Workshops, which gathered local and national marine stakeholders to the development in order that shipping and navigation hazards could be identified, and subsequently included in a hazard log. This ensured that expert opinion and local knowledge was incorporated into the hazard identification process, and that the hazard log is site-specific.

380. The hazard log details the risks associated with each hazard and the industry standard plus additional commitments required to reduce the risks to ALARP, as identified in the Hazard Workshops.

18.1 Hazard Workshop Attendance

381. The first Hazard Workshop was held in London on 27th June 2019. The second Hazard Workshop (undertaken following the proposed reduction to the Hornsea Four array area boundary resulting in the gap between Hornsea Four and Hornsea Project Two) was undertaken via teleconferencing (due to restrictions incurred by the COVID-19 pandemic) on 28th May 2020. It is noted that a minor change to the Hornsea Four array area boundary at the north western extent has not been discussed at a Hazard Workshop with the MCA and Trinity House in agreement that this further change was not of material effect for shipping and navigation receptors.

382. The organisations which attended the Hazard Workshops (either one of or both) were as follows:

- MCA;
- Trinity House;
- UK Chamber of Shipping;
- ABP;
- DFDS Seaways;
- Boston Putford Offshore Safety;
- Danish Shipping;
- Perenco;
- Premier Oil;
- Alpha Petroleum;
- NEO Energy; and
- Offshore Design Engineering (ODE).

383. The CA, RYA and National Federation of Fishermen's Organisations (NFFO) were invited to the Hazard Workshops but were unable to attend. However, these organisations were included in consultation relating to the hazard log during Section 42 Consultation. Regular Operators were given the opportunity to attend the Hazard Workshops (see Appendix D) but only DFDS Seaways and Boston Putford Offshore Safety did so. Additionally, National Grid and Energinet – the partners for the Viking Link Interconnector – were invited to the second Hazard Workshop but did not attend (a separate workshop specifically with National Grid and Energinet was undertaken in December 2020).

18.2 Hazard Workshop Process

384. During the Hazard Workshops, key maritime hazards associated with the construction and operation and maintenance of Hornsea Four were identified and discussed. Where appropriate, hazards were considered by vessel type, to ensure risk control options could be identified on a type-specific basis (for example, risk controls for commercial ferries may differ from those considered appropriate for other commercial vessels).

385. Following the first Hazard Workshop, the risks associated with the identified hazards were ranked based upon the discussions held during the workshop, with appropriate commitments identified. The rankings were then provided to the Hazard Workshop invitees for comment and their feedback incorporated into this NRA. Following the second Hazard Workshop, the identified hazards and associated risks from the first Hazard Workshop were reviewed in light of the change to the Hornsea Four array area boundary. The rankings were then updated and again provided to the Hazard Workshop invitees for comment and their feedback incorporated into this NRA.

18.3 Hazard Log

386. The hazard log was compiled following the first Hazard Workshop based upon the discussions held and was updated following the second Hazard Workshop. It was also reviewed following the further change to the Hornsea Four array area boundary noted in Section 18.1. The hazard log has been used to inform the impact assessment undertaken in **Volume A2, Chapter 7: Shipping and Navigation** and is provided in full in Appendix B.

19 Cumulative and Transboundary Overview

387. Cumulative effects have been considered for activities in combination and cumulatively with Hornsea Four. This section provides an overview of the baseline used to inform the CEA including the pre wind farm vessel routeing and projects and proposed developments screened in to the CEA based upon the criteria outlined in Section 3.3. It is noted that given the unique nature of shipping and navigation receptors the bespoke tiering system outlined in Section 3.3 has been applied.

388. The full list of reasonably foreseeable projects that have been identified in relation to the offshore environment (and put through the screening process) are set out in **Volume A4, Annex 5.3: Offshore Cumulative Effects** and are presented in a series of maps within **Volume A4, Annex 5.4: Location of Offshore Cumulative Schemes**.

19.1 Screened In Developments

19.1.1 Other Offshore Wind Farms

389. In addition to Hornsea Four, there are a number of offshore wind farm developments within the North Sea, both within UK and non-UK waters. Table 19.1 includes details of the offshore wind farm developments (including the CEA tier applied as outlined in Section 3.3) where a cumulative or in combination activity has been identified based upon the location and distance from Hornsea Four. The project statuses provided are correct as of May 2021.

390. Figure 19.1 presents the locations of these developments.

19.1.2 Oil and Gas Infrastructure

391. There are a large number of oil and gas surface platforms within the North Sea, both within UK and non-UK waters. However, given that all oil and gas surface platforms in proximity to Hornsea Four are operational or under construction (including the Tolmount gas platform located in close proximity to the Hornsea Four HVAC booster station search area), they are all considered part of the baseline (see Section 10.2) and therefore no oil and gas infrastructure has been screened in to the CEA. This is based on project statuses as of May 2021.

19.1.3 Carbon Capture Infrastructure (Surface Piercing)

392. Endurance (Carbon Capture and Storage Lease Area) has published limited information (due to being pre-planning) with regards to its proposals with construction estimated to commence in 2023 and be operational by 2026. The development will include either several small, unmanned installations (platforms) or fewer (one or two) larger hub unmanned installations. Table 19.1 includes details of the Endurance (including the CEA tier applied as outlined in Section 3.3) where a cumulative or in combination activity has been identified based upon the

location and distance from Hornsea Four. The project status provided is correct as of May 2021.

393. Figure 19.1 presents the location of the development.

19.1.4 Submarine Cables and Pipelines

394. There are a number of existing submarine cables and pipelines located in proximity to Hornsea Four. Given that these infrastructure are already *in situ*, they are considered as part of the baseline (see Section 10.4). However, at the time of writing, the Viking Link Interconnector is still under construction and, given that concerns have been raised during consultation, this development has therefore been screened in to the CEA. Table 19.1 includes details of the Viking Link Interconnector (including the CEA tier applied as outlined in Section 3.3) where a cumulative or in combination activity has been identified based upon the location and distance from Hornsea Four. The project status provided is correct as of May 2021.

Table 19.1 Summary of developments screened in to CEA

Tier	Project	Project Type	Project Status	Closest Distance			Data Confidence Level i.e. Location or Status
				Hornsea Four Array Area (km)	Hornsea Four Offshore ECC (km)	Hornsea Four HVAC Booster Station Search Area (km)	
1	Dogger Bank A	Offshore wind farm	Consented	66	84	108	High
	Dogger Bank B	Offshore wind farm	Consented	76	94	112	High
	Hornsea Three	Offshore wind farm	Consented	46	60	117	High
	Viking Link Interconnector	Submarine cable	Under construction	2	4	42	Medium
2	Dudgeon Extension	Offshore wind farm	Pre-planning application	69	69	93	High
	Sofia	Offshore wind farm	Pre-construction	98	114	144	High
3	Endurance	Carbon capture and storage	Pre-planning application	0	2	19	Medium

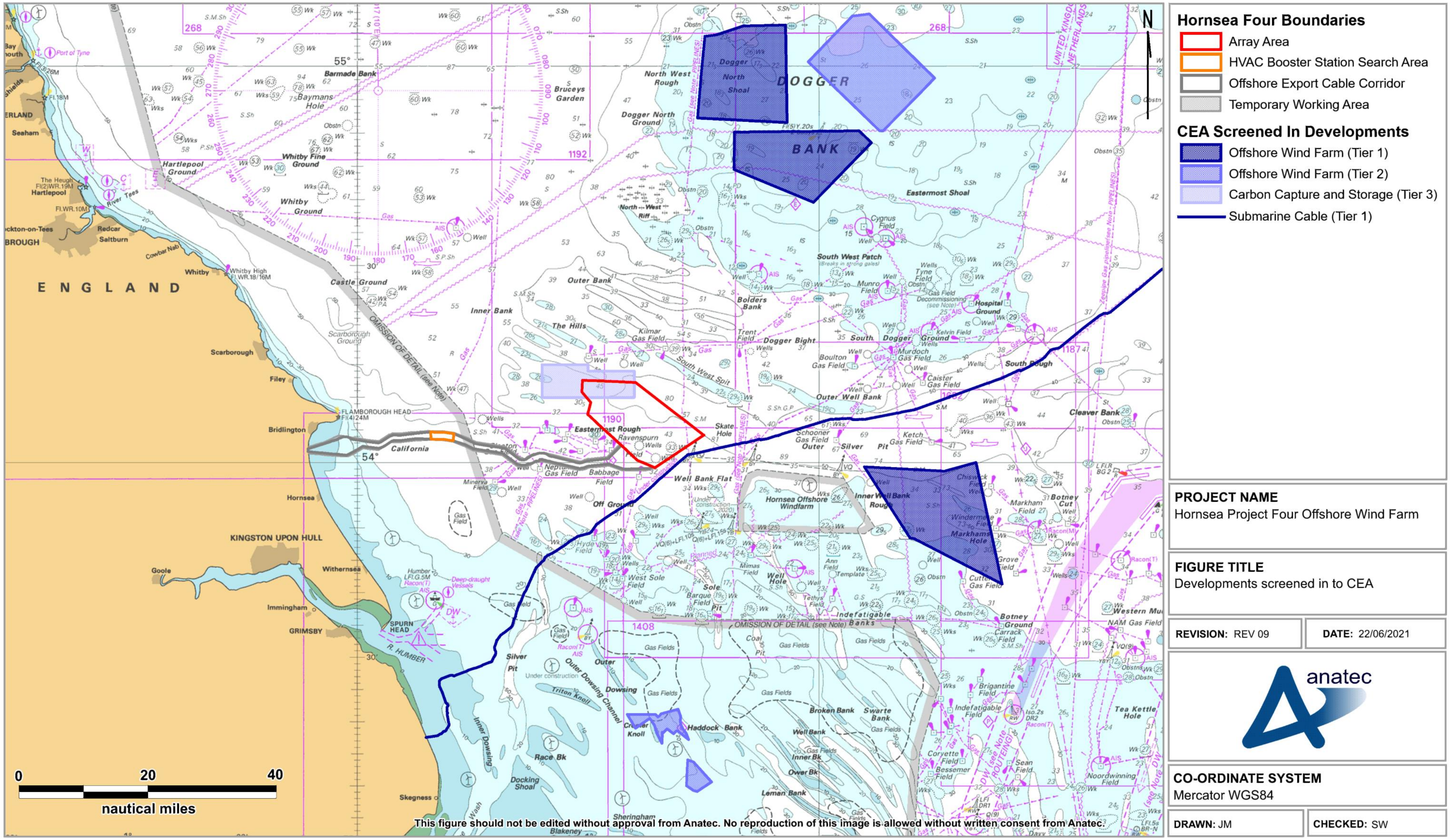


Figure 19.1 Developments screened in to CEA

19.2 Cumulative Pre-Wind Farm Routeing

19.2.1 Hornsea Four Array Area

395. Main route identification has been undertaken for the Hornsea Four cumulative shipping and navigation study area. This consisted of extending the array area pre wind farm main routes identified in the baseline assessment of Hornsea Four in isolation (see Section 15.1.5) to ensure they are captured throughout the larger study area.

396. Given that the vessel traffic surveys only provide a high level of coverage in proximity to the Hornsea Four array area (around 10 nm) the following secondary sources have been used to assist establishing the main route positions throughout the wider study area:

- NRA vessel traffic survey data from previous Hornsea developments:
  - Hornsea Project One (Anatec, 2013);
  - Hornsea Project Two (Anatec, 2015); and
  - Hornsea Three (Anatec, 2018).
- *SNSOWF Cumulative Navigational Issues in the Southern North Sea* (Anatec, 2013); and
- Anatec's ShipRoutes database (2020).

397. Although some of these sources are several years old, they are not considered obsolete given both the habitual nature of vessel routeing and their role as secondary sources supporting the vessel traffic survey data collected for Hornsea Four.

398. Figure 19.2 presents a plot of the main routes within the Hornsea Four cumulative shipping and navigation study area.

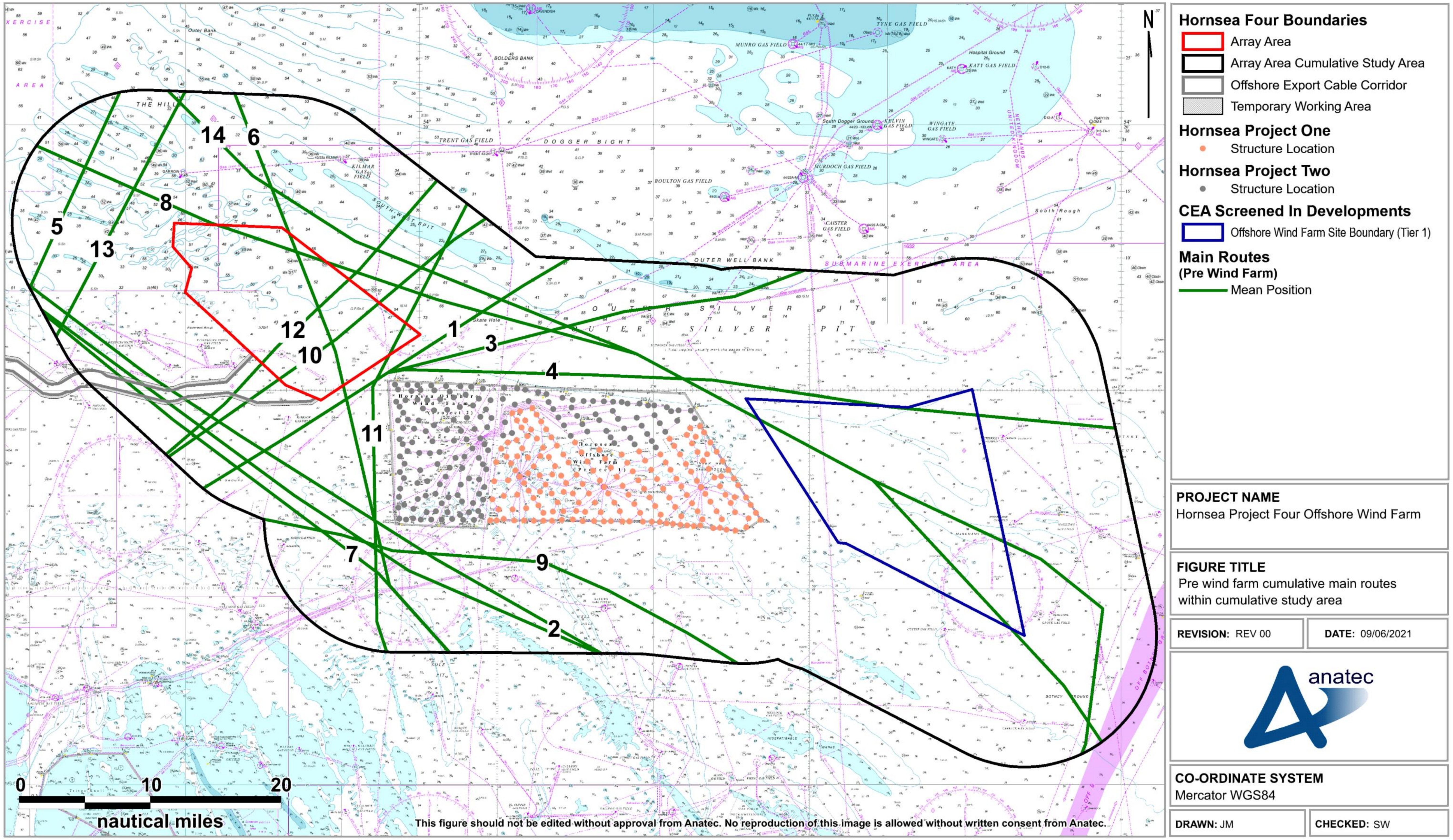


Figure 19.2 Pre wind farm main routes within Hornsea Four cumulative shipping and navigation study area

399. Descriptions of the traffic on each of the main routes are provided in Table 15.1.

400. Table 19.2 summarises which CEA developments each of the main routes would be required to deviate around. As per the methodology for re-routeing (see Section 20.5), it has been assumed that any main route passing within 1 nm of an offshore installation will require a deviation.

401. Those CEA developments for which there are not any main routes passing through in the pre wind farm scenario are not included in Table 19.2.

Table 19.2 Cumulative routeing through developments for Hornsea Four array area

Route Number	Average Transits per Day	Main Ports	CEA Developments	
			Hornsea Three	Dogger Bank B
1	2	Immingham–Gothenburg		
2	2	Newcastle–Amsterdam		
3	1 to 2	Immingham–Esbjerg		
4	1 to 2	Immingham–Hamburg	✓	
5	1	Immingham–north Norway ports		
6	1	Grangemouth–Rotterdam		
7	1	Tees–Rotterdam		
8	1	Tees–Rotterdam	✓	
9	0 to 1	Immingham–Antwerp		
10	0 to 1	Immingham–Baltic ports		
11	0 to 1	Great Yarmouth–Trent gas field		
12	0 to 1	Immingham–Baltic ports		
13	0 to 1	Immingham–northern Norway port.		✓
14	0 to 1	Tees–Amsterdam	✓	

19.2.2 Hornsea Four HVAC Booster Station Search Area

402. There are no CEA developments in proximity to the Hornsea Four HVAC booster station search area (the nearest CEA development is the Tier 3 Endurance carbon capture and storage project located approximately 15 nm from the HVAC booster station search area). Therefore, no further assessment has been undertaken to identify main routes at the cumulative level – the existing baseline is considered suitable.

403. Figure 15.46 presents a plot of the main routes within the Hornsea Four HVAC booster station search area shipping and navigation study area.

19.3 Safety Case for the Gap Between Hornsea Four and Hornsea Project Two

404. A reduction in the size of the Hornsea Four array area to facilitate a gap between Hornsea Four and Hornsea Project Two is considered a fundamental change to the project design (not present at PEIR) to mitigate the transboundary impact of cumulative deviations to vessels due to the presence of Hornsea Four and other nearby developments, which is of a commercial nature. The gap has been developed in consultation with relevant shipping stakeholders including the MCA, Trinity House and DFDS Seaways, the prominent vessel operator in the area. It is therefore anticipated that some regular commercial vessel traffic (including commercial ferries operated by DFDS Seaways) will incorporate the gap into their passage plans and hence it is necessary to ensure that the navigational risk introduced by the inclusion of the gap is not significant.

405. It is noted that the gap is discussed in this subsection only in relation to its navigational safety aspect. The commercial impact and impacts on oil and gas receptors are not considered within the scope of the NRA, and are instead discussed in full within **Volume A2, Chapter 7: Shipping and Navigation** and **Volume A2, Chapter 11: Infrastructure and Other Users**, respectively.

19.3.1 Overview of the Gap Between Hornsea Four and Hornsea Project Two

406. The gap between Hornsea Four and Hornsea Project Two is located south of the Hornsea Four array area. Figure 19.3 presents an overview of the gap including its dimensions and relevant navigational features. As noted in Section 10.3, the construction buoys associated with Hornsea Project Two will be removed following the commissioning of the development.

407. The total length of the gap is 8.0 nm (measured as the length of the southern boundary of the Hornsea Four array area). The narrowest width of the gap is 2.2 nm (measured as the shortest length between the southern boundary formed by the centre point of Hornsea Four structures and the centre point of the north western structure of Hornsea Project Two), but the width grows from the narrowest point in a 'bow tie' shape, with a maximum width of 10.9 nm and 4.4 nm at each end of the gap, respectively.

408. The water depth within the gap varies between 30 and 43 m below CD.

409. There is one existing submarine cable passing north-south through the gap and one under construction submarine cable as of June 2021 (the Viking Link Interconnector) which passes south west-north east through the gap.

410. There are four charted wrecks located within the gap, all located towards the southern extent, away from the main component of the gap between Hornsea Four and Hornsea Project Two. Another charted wreck, with depth 36 m below CD, is located immediately west of the gap.

411. The Babbage surface platform is located approximately 2.8 nm south west of the gap. There are no other surface installations in close proximity to the gap.

19.3.2 Potential Users

412. To ensure all relevant vessels are considered, long-term AIS data (covering 13 months between January 2019 and February 2020) collected from the SOV for the construction phase of the nearby Hornsea Project One has been analysed, with any significant downtime (generally due to the vessel leaving site) filtered out. This gave a total of 323 full days of data.

413. Using a gate analysis, tracks for commercial vessels transiting in a north east-south west direction were considered to be potential users of the gap between Hornsea Four and Hornsea Project Two and were analysed further. This filtering step was undertaken conservatively, including the incorporation of vessels passing through the location of Hornsea Project Two which may choose to use the gap as well as vessels further north which may in reality choose to transit around the north western corner of the Hornsea Four array area. Indeed, the vessel traffic survey data collected following the start of Hornsea Project Two construction (see Section 7) indicates that some vessels may choose to pass south of all the existing Hornsea developments rather than use the gap between Hornsea Four and Hornsea Project Two.

414. An average of six transits per day by potential gap users were recorded throughout the 323-day period. Approximately 81% of the potential gap users were cargo vessels and 49% of all potential gap users were commercial ferries. DFDS Seaways accounted for approximately 94% of commercial ferry traffic, and therefore 46% of all potential gap users.

415. The average length of potential gap users was 165 m with the majority (approximately 72%) under 200 m length. The average speed of potential gap users was 14.8 kt, rising to 18.6 kt when considering commercial ferries only. Based on the total length of the gap this translates to an average transit time of 33 minutes, assuming no change in speed is applied in the post wind farm scenario.

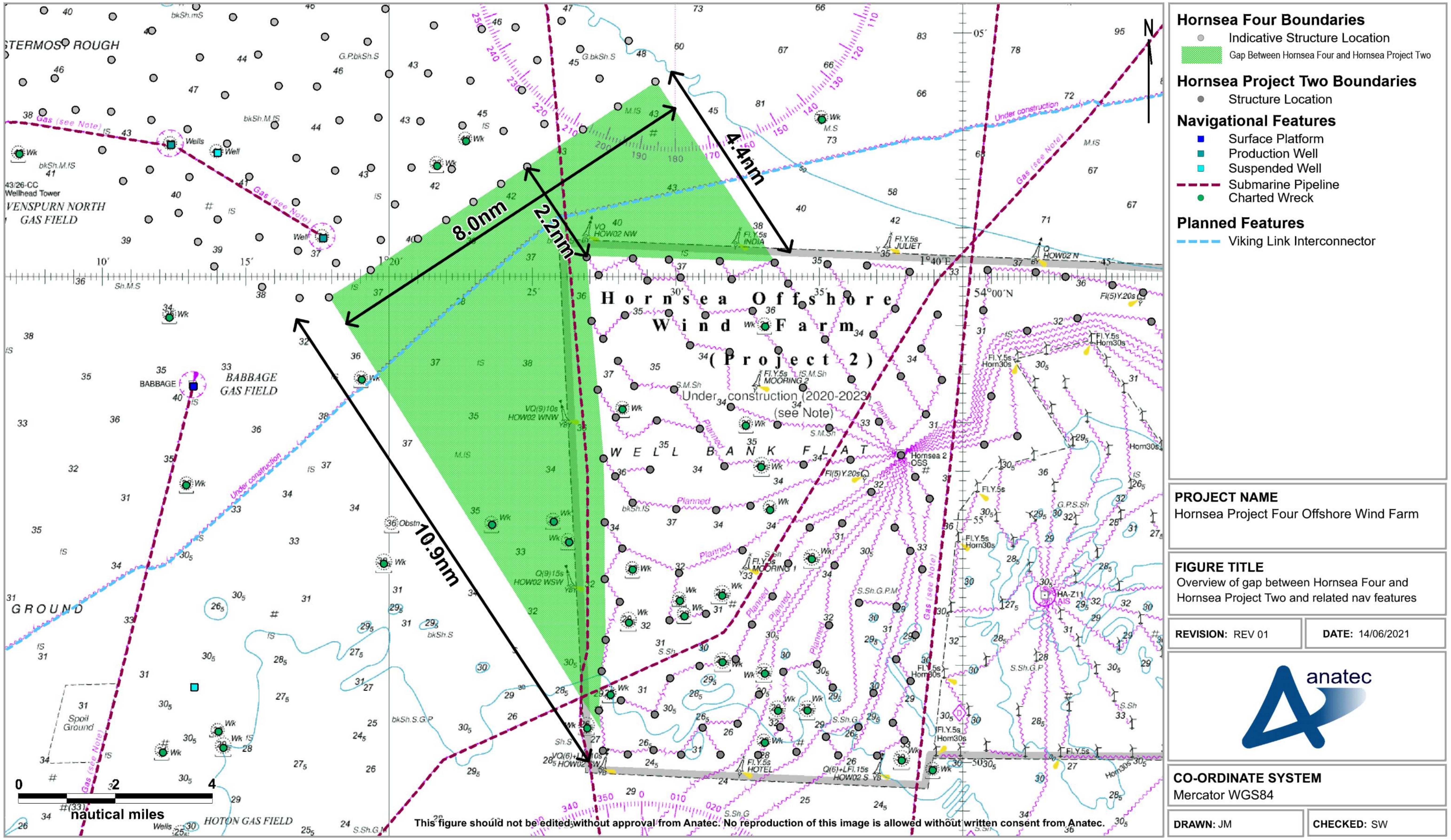


Figure 19.3 Overview of gap between Hornsea Four and Hornsea Project Two and related navigational features

19.3.3 Probability of an Encounter

416. Anatec's *Time Analyser* has been run to calculate the number of vessels present within the gap between Hornsea Four and Hornsea Project Two in the same hour throughout the 323-day (7,752 hours) period. The breakdown of the number of transits per hour is presented in Table 19.3.

Table 19.3 Breakdown of number of transits within same hour within the gap between Hornsea Four and Hornsea Project Two

Number of Transits within Same Hour	Number of Occurrences	Percentage (%)
0	6,059	78.2
1	1,464	19.3
2	180	2.3
3	19	0.2

417. From the data, there is a 2.5% probability of two or more vessels experiencing an encounter within the gap. This is considered a conservative calculation given:

- The use of one-hour windows when average speed data for potential gap users suggests transits through the gap are likely to take significantly less time (average 34 minutes); and
- The vessel traffic data presented in Section 15.1 suggests that some vessels may choose to pass south of all the existing Hornsea developments rather than use the gap – in particular Route 9 (Immingham–Antwerp) was not observed in the vessel traffic analysis undertaken at PEIR (pre Hornsea Project Two construction) and may have been established as an alternative to passing at the north western corner of Hornsea Project Two.

19.3.4 Application of Permanent International Association of Navigation Congresses' Guidance

418. During consultation with DFDS Seaways – the leading vessel operator in the area – a width calculation for collision avoidance involving a complete round turn to starboard (as per the COLREGs for facilitating passing encounters) provided in *Guidance on the Interaction between Offshore Wind Farms and Maritime Navigation* (PIANC, 2018) was heavily referenced.

419. As illustrated in Figure 19.4, the calculation assumes a 500 m safety margin from the wind farm structures. This has been used to ensure that calculations relating to safe round turns are not impacted by blade overfly, micro-siting or statutorily approved safety zones (i.e. 500 m during major maintenance activities). The round turn requires a six vessel length diameter and is preceded by a 0.3 nm distance for an initial deviation prior to undertaking the round turn.

420. It is noted that this guidance is designed for vessels undertaking collision avoidance action within a TSS running parallel with the wind farm. There is no such regulated feature within the gap between Hornsea Four and Hornsea Project Two (nor planned based on MCA feedback – see Section 19.3.9.2), and therefore vessels have greater flexibility in altering their course where collision avoidance action is necessary.

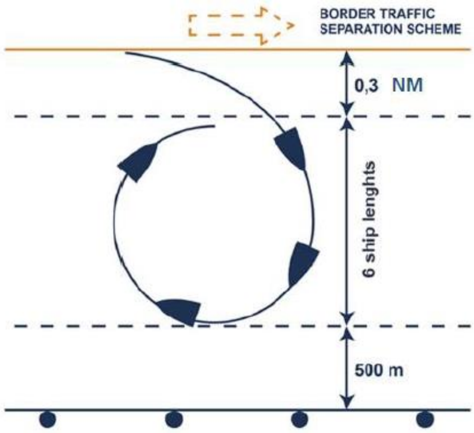


Figure 19.4 Sea space required for full round turn (PIANC, 2018)

421. Figure 19.5 presents this PIANC calculation applied to the gap using the average vessel length computed in Section 19.3.2 of 165 m. It has been assumed that the 500 m safety margin is measured from the centre point of structures, as per the standard measurement for offshore legislation. It is noted that 165 m has been selected following a statistical analysis of vessel lengths operating in the area but does not give any indication of the maximum length of vessel that could use the gap, noting that there will be no restrictions on use as discussed at the second Hazard Workshop in May 2020.

422. It can be seen that with the guidance applied and assuming the vessel starts its collision avoidance manoeuvre from the outer extremity of the fairway, there is a 1.69 nm distance within the gap for which the fairway width is below four vessel lengths, a width provided by DFDS Seaways as sufficient. This corresponds to 20% of the total gap length. With no restriction on the position in the fairway from which the collision avoidance manoeuvre begins, there is a 0.24 nm (444 m) distance within the gap for which a round turn cannot be completed without breaching the 500 m safety margin, corresponding to 3% of the total gap length.

423. A round turn as prescribed by the PIANC guidance and with a fairway width of four vessel lengths can be completed for 80% of the gap's length. As illustrated in Figure 19.5, the effective fairway width is significantly more than four vessel lengths throughout the majority of the gap, meaning that vessel Masters have greater flexibility in their decision-making process, both when passage planning and when approaching the gap during their transit.

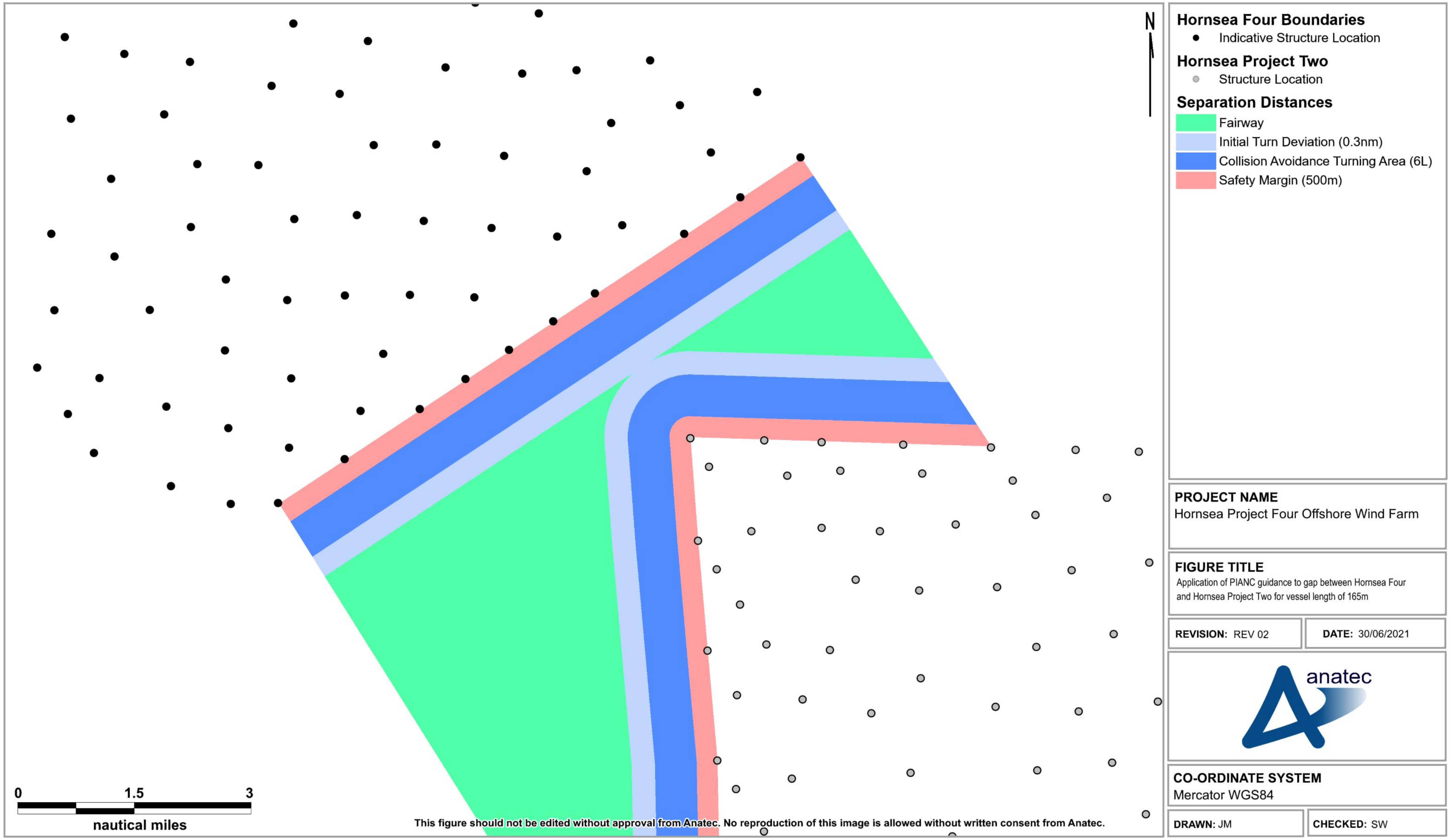


Figure 19.5 Application of PIANC guidance to gap between Hornsea Four and Hornsea Project Two for vessel length of 165 m

19.3.5 Application of International Regulations for Preventing Collisions at Sea

424. The COLREGs are the rules and regulations that help regulate vessel traffic movements throughout the world. It is therefore important that the gap between Hornsea Four and Hornsea Project Two does not prevent a vessel from being able to comply with these regulations. Although the COLREGs do not make specific provision for a separation through offshore wind farms such as the gap, they do lay down rules for navigating within a narrow channel which may be somewhat applicable.

19.3.5.1 Rule 9a

425. Rule 9a states:

> *A vessel proceeding along the course of a narrow channel or fairway shall keep as near to the outer limit of the channel or fairway which lies on her starboard side as is safe and practicable.*

426. However, a vessel should not enter the gap unless it is confident that it can alter course and manoeuvre as required to comply with the collision regulations and avoid a collision. It is noted that the use of "*outer limit*" is analogous with the assumption on vessel position when starting a full turn in the PIANC width calculation.

19.3.5.2 Rule 9b and 9c

427. Rule 9b states:

> *A vessel of less than 20 m in length or a sailing vessel shall not impede the passage of a vessel which can safely navigate only within a narrow channel or fairway.*

428. Furthermore, Rule 9c states:

> *A vessel engaged in fishing shall not impede the passage of any other vessel navigation within a narrow channel or fairway.*

429. Although the COLREGs give priority to vessels navigating within a narrow channel (in this case the gap between Hornsea Four and Hornsea Project Two) it is still prudent for the purpose of minimising the navigational risk to consider any dense activity involving relevant small craft. From analysis of non-commercial vessel traffic (see Section 15.1), it can be seen that fishing and recreational vessel activity at the relevant array area boundaries is not substantial, and the bow tie shape of the gap allows users sufficient time to alter their course upon passing the narrowest point of the gap, should this be required, and therefore the presence of small craft activity is not likely to impede a gap user's passage.

19.3.6 Effect of Non-Transit Users

430. As indicated by the COLREGs, the presence of a high concentration of active vessels not transiting the gap between Hornsea Four and Hornsea Project Two may pose an additional manoeuvring concern and restrict available sea room for those vessels which are transiting the gap. There is also a risk associated with smaller vessels (such as fishing vessels and recreational craft) utilising the gap for transit and therefore sharing sea space with larger vessels.

19.3.6.1 Fishing Vessels and Recreational Vessels

431. From the vessel traffic analysis (see Section 15.1) there is not a substantial volume of fishing vessels and recreational vessels located at the relevant array area boundaries and therefore there is unlikely to be any notable interaction with gap users. Given the bow tie shape of the gap and the considerable minimum spacing between structures within both the Hornsea Four and Hornsea Project Two arrays, this should also help with earlier detection of any smaller craft crossing the gap, thus ensuring that any gap user is able to safely alter their course to avoid an encounter.

432. Moreover, higher density areas of fishing vessel and recreational vessel activity are generally at a great enough distance from the array area that any gap user should again be able to safely make course alterations as required. Also, from consultation with VISNED, the presence of the wind farm and in particular a dense perimeter of structures may lead to fishermen choosing to avoid the array, potentially reducing the density of fishing activity post wind farm.

19.3.6.2 Project Vessels

433. Although project vessels may operate within the gap, vessel movements will be made in line with the commitments included as part of Hornsea Four (see Section 23) including compliance with the COLREGs and MGN 372 (MCA, 2008).

434. The Hornsea Project Two ES (SmartWind, 2015) considered the impact of its own construction and operation and maintenance vessels and found impacts to be not significant under EIA terms. A worst case estimation of:

- A maximum of 84 vessels on site at any one time, 6,200 round trips over the course of construction (based on a six-and-a-half year construction period); and
- Up to 2,817 operation and maintenance vessel return trips per year.

435. It is noted that mitigations included the use of marine coordination to manage those vessel operations and ensure that they did not impact on third party vessels. This marine coordination practice will work in conjunction with the commitments as referenced in Paragraph 433.

19.3.7 Radar Interference

436. For vessels transiting through the gap between Hornsea Four and Hornsea Project Two there may be a potential for increased exposure to Radar interference. This is considered fully in Section 17.7 as part of the wider assessment of risks associated with navigation, communication and position fixing equipment and is not considered to have a significant effect.

19.3.8 Electromagnetic Interference

437. For vessels transiting through the gap between Hornsea Four and Hornsea Project Two there may be a potential for increased exposure to electromagnetic interference due to the Viking Link Interconnector[4], resulting in an effect on the operation of compasses.

438. Taking into account the main route deviations following the development of Hornsea Four (see Section 20.5), there is not anticipated to be any significant change in the volume of vessel traffic passing over the Viking Link Interconnector, noting that much of the relevant vessel traffic already passes over the Viking Link Interconnector location following the start of Hornsea Project Two construction. Therefore, the risk of electromagnetic interference due to the Viking Link Interconnector is not anticipated to change significantly from the baseline scenario.

439. Receptors of this impact are limited to smaller craft (primarily recreational vessels) which rely on a magnetic compass. All other vessels mandatorily carry a gyrocompass which is not affected by ferrous materials. Given the limited number of small craft recorded within and in proximity to the gap (as per the vessel traffic survey analysis undertaken in Section 15.1) and the gap being designed primarily for transit use by larger commercial vessels, the frequency of a vessel being present which may be navigationally affected by electromagnetic interference is very low.

440. As noted in Section 17.6, there are a number of factors with respect to cables that may affect compass deviation. Water depth is considered the leading factor, and given the charted water depth within the gap (minimum 30 m below CD as per Section 19.3.1 but minimum 36 to 38 m below CD in proximity to the Viking Link Interconnector), the impact – should a small craft susceptible to the impact pass over the location of the Viking Link Interconnector – is likely to be minimal.

19.3.9 Consultation

441. Consultation in relation to the inclusion of a gap between Hornsea Four and Hornsea Project Two in some form has been ongoing with the primary affected operator – DFDS Seaways – from early in the process. Although the inclusion of a gap was not initially incorporated into the design envelope, concerns relating to

[4] It is noted that no submarine cables associated with Hornsea Four or Hornsea Project Two will cross the gap and therefore the Viking Link Interconnector is the only such feature which will be located within the gap.

the commercial impact of vessels re-routeing around the Hornsea Four array area were noted. Following the PEIR stage and Section 42 consultation the inclusion of a gap was considered to be the most effective mitigation for the commercial impact and new consultation to ratify its design both for navigational safety and commercial purposes was undertaken.

19.3.9.1 DFDS Seaways

442. Given that DFDS Seaways operated vessels were the most affected receptor with regards to the commercial impact of vessels re-routeing around the Hornsea Four array area it was considered imperative to maintain an open line of communication when considering the gap between Hornsea Four and Hornsea Project Two. Regular and ongoing meetings have been undertaken with DFDS Seaways, with design concepts shared and discussions held on the application of relevant guidance. DFDS Seaways considered the PIANC guidance the most relevant, and therefore it has been considered fully in this safety case.

443. During consultation, DFDS Seaways indicated that the six lengths allocated for a round turn prescribed by the PIANC guidance is conservative for their vessels which would likely be able to complete such a manoeuvre with a smaller diameter.

19.3.9.2 Maritime and Coastguard Agency and Trinity House

444. The MCA have clarified that their interest in any gap is in relation to the safety of navigation rather than any commercial issues. The MCA have considered the decision to explore the inclusion of the gap as encouraging and suggested that the PIANC guidance would be a useful tool for the risk assessment – this has been considered in Section 19.3.4.

445. The MCA have also confirmed that the implementation of a TSS is neither necessary nor appropriate for the gap, although the implementation of a recommended route could be a simpler option.

446. Trinity House have acknowledged that since the gap is not recognised as a navigational corridor there would be no provision for specialised aids to navigation.

19.3.9.3 Norwegian Shipowners’ Association and Danish Shipping

447. The Norwegian Shipowners’ Association (NSA) and Danish Shipping both suggested the inclusion of a navigational corridor in their respective Section 42 consultation. A corridor width of 2.2 nm was suggested, matching the width of the proposed gap at its narrowest point.

19.3.9.4 Hazard Workshop and Post Meeting Correspondence

448. The second Hazard Workshop held in May 2020 provided stakeholders with an opportunity to comment on the proposed gap.

449. DFDS Seaways expressed satisfaction with the work undertaken in relation to the gap and the fairway width suggested by the PIANC width calculation, noting that there may be additional options available to Masters to reduce navigational risk that would be considered through dynamic risk assessment. DFDS Seaways also confirmed that an "*extreme emergency*" would be necessary before one of their vessels would drop anchor within the gap and subsequently the likelihood of an anchor snagging incident was considered remote. Assuming that there would be no size restrictions for users above and beyond those related to water depth, DFDS Seaways consider the gap suitable for navigation by their vessels on routes between Immingham and Scandinavia.

450. Boston Putford Offshore Safety considered the distance between structures to be sufficient and agreed with DFDS Seaways' view that the likelihood of an anchor needing to be dropped in the gap is remote.

451. Danish Shipping confirmed support for the gap, and in particular expressed satisfaction with the incorporation of the 2.2 nm width suggested during consultation and the inclusion of thorough calculations in determining the gap's design.

452. The UK Chamber of Shipping confirmed support for the gap and expressed gratitude for the commitment shown by the Applicant in working together with other marine stakeholders in developing the gap.

453. ABP advised that they would be guided by the views of their customers and port users who are navigational users of the North Sea, but added that they consider the gap to be very helpful and should greatly assist commercial shipping stakeholders.

454. The CA confirmed support for the gap, noting that the gap would offer additional options for smaller vessels, with assurance that the likelihood of encountering larger craft when navigating within the array would be limited given that such traffic would choose to utilise the gap.

455. The MCA confirmed support for the gap concept both in terms of its benefit for vessels and SAR helicopter operations since it provides an alternative HRA.

456. Trinity House expressed content in general with the gap proposal, but did express concern with the methodology for measuring the minimum width of the gap including the presence of blade overfly.

19.3.9.5 National Grid and Energinet (Viking Link Interconnector)

457. A workshop was undertaken with National Grid and Energinet (the partners for the Viking Link Interconnector) in December 2020 at which concerns were raised in relation to collision and anchoring risk as well as electromagnetic interference

arising from the exposure of an approximately 15 km stretch of the cable. Three potential mitigation options were suggested by Viking Link:

- Move the gap;
- Cover the 15 km of the cable with rock berm; or
- Introduce some form of traffic routeing measure, e.g. TSS or precautionary area.

458. Regarding the potential for moving the gap, consultation with DFDS Seaways, the MCA and Trinity House assisted in defining the location of the gap and at the Hazard Workshop (to which National Grid were invited) the proposed location was generally agreeable, noting that users had a preference for the gap to be located where vessel traffic currently passes and clear of fixed surface assets.

459. Regarding the option to provide additional cable protection in the form of rock berm, the water depth within the gap (as noted in Section 19.3.8) is considered sufficient to ensure that any electromagnetic interference is likely to be minimal. Additionally, the likelihood of anchoring within the gap (as noted in Section 19.3.9.4) is very low with the subsequent likelihood of an anchor snagging incident occurring considered remote. Therefore, with no significant increase in the risk of a passing vessel experiencing some form of interaction with the cable, there is no sufficient cause for the provision of additional cable protection.

460. Regarding the placement of an IMO routeing measure (such as a TSS), these were discussed with the MCA and Trinity House and at the Hazard Workshop where it was noted that such a measure would require national and international support and should be based on a safety case with a demonstrable need. The gap does not demonstrate the need for a routeing measure given that risks are assessed to be ALARP following consultation and the undertaking of the safety case in the NRA.

461. Moreover, the safety case has not demonstrated the need for additional control measures for vessel traffic (outside of those provided by COLREGs), noting that VTS (suggested as a mitigation measure during consultation by Viking Link) are not permitted by SOLAS outside of territorial waters in line with United Nations Convention for the Law of the Sea (UNCLOS).

462. Finally, additional aids to navigation, i.e. lateral marks, were discussed at the Hazard Workshop but Trinity House considered standard OREI marking (IALA O-139) to be sufficient.

463. In relation to anchoring, the main route deviations following the development of Hornsea Four (see Section 20.5) indicate a small and not significant change in the volume of vessel traffic passing through the gap between Hornsea Four and Hornsea Project Two.

464. This small change is not anticipated to result in an increase in the number of emergency anchoring occurrences, with DFDS Seaways indicating comfort with the

anchoring situation within the gap. Furthermore, with the application of good seamanship, bridge procedures and penetration depths assumed to have been assessed as part of the Viking Link CBRA (noting that the size of vessel anchors is not anticipated to increase materially), the anchoring risk is considered not to be significant.

465. In relation to electromagnetic interference, this is not considered to be significant based on the assessment undertaken in Section 19.3.8.

19.3.10 Commitments Included as Part of Hornsea Four

466. The following commitments included as part of Hornsea Four (and detailed in **Volume A4, Annex 5.2: Commitments Register**) will assist in ensuring that the navigational risk associated with the gap between Hornsea Four and Hornsea Project Two is ALARP:

- Advance warning and accurate location details of construction, maintenance and decommissioning operations, associated Safety Zones and advisory passing distances will be given via Notifications to Mariners and Kingfisher Bulletins (Co89);
- Aids to navigation (marking and lighting) will be deployed in accordance with the latest relevant available standard industry guidance and as advised by Trinity House, MCA, Civil Aviation Authority (CAA) and MOD as appropriate. This will include a buoyed construction area around the array area and the HVAC booster station in consultation with Trinity House (Co93);
- Hornsea Four will ensure compliance with MGN 654 (MCA, 2021) where appropriate (Co99); and
- Hornsea Four vessels will comply with MGN 372 (MCA, 2008) or the latest relevant available guidance where appropriate (Co177).

467. The buoyed construction area size and location will consider the need to maintain safe navigation through the gap and will be determined in consultation with the MCA and Trinity House.

468. It is assumed that project vessels will comply with the COLREGs and SOLAS. Consideration will be given to the use of designated routes to and from the Hornsea Four array area for project vessels, with specific entry and exit points in and out of the array to minimise the collision risk within the gap.

469. No infrastructure (including subsea cables) relating to the Hornsea projects can be located outside of their respective Order Limits, and therefore within the gap.

470. It is noted that marine coordination for Hornsea Four will be shared with Hornsea Project Two, and therefore there will be a good level of communication between the respective developments.

19.3.11 Conclusion

471. This safety case has considered the following:

- Relevant navigational features within and in proximity to the gap between Hornsea Four and Hornsea Project Two (including planned features);
- Number, size and speed of potential gap users based on long-term AIS data;
- Probability of an encounter between vessels within the gap based on long-term AIS data;
- Application of relevant guidance and legislation including the PIANC width calculation for collision avoidance and the COLREGs;
- Nature of potential non-transit gap users;
- Radar interference;
- Electromagnetic interference;
- Consultation undertaken with relevant stakeholders including DFDS Seaways, MCA and Trinity House as well as the outputs of the Hazard Workshop; and
- Commitments included as part of Hornsea Four.

472. Although the gap does not satisfy the PIANC width guidance fully, there are limitations in its application given that the gap is not strictly a navigational corridor with parallelogram shape. Indeed, the gap offers benefits not applicable to a navigational corridor, most notably a greater flexibility for vessels to make course adjustments. Moreover, the study of potential gap users suggests that the likelihood of an incident within the gap is low and existing precedent suggests such a feature can safely reduce the magnitude of vessel displacement. Taking into account the positive consultation undertaken with relevant stakeholders (including the leading vessel operator in the area) and commitments included as part of Hornsea Four, it is concluded that the gap does not pose a significant risk to safe navigation.

20 Future Case Vessel Traffic

473. This section presents the future case level of activity within and in proximity to the Hornsea Four array area and HVAC booster station search area and the anticipated shift in the mean positions of the main commercial routes post wind farm.

474. The future case activity and routeing has been input into the collision and allision risk modelling and is considered throughout the impact assessment undertaken in **Volume A2, Chapter 7: Shipping and Navigation**, where future case refers to the assessment of risk based upon the predicted growth in future shipping densities and traffic types as well as foreseeable changes in the marine environment, as discussed in the following subsections.

20.1 Increases in Traffic Associated with Ports

475. Due to the distance offshore of the Hornsea Four array area, it is considered unlikely that any increase in port traffic (i.e. vessels entering and exiting ports) would directly impact on the general traffic levels around the Hornsea Four array area and offshore ECC; therefore the impact assessment considers an indicative 10% increase in traffic associated with ports.

20.2 Increases in Commercial Fishing Vessel Activity

476. An indicative 10% increase in commercial fishing vessel transits is considered in the impact assessment to demonstrate potential impacts (in line with other renewables assessments). This value is used due to there being limited reliable information on future activity levels upon which any firm assumption could be made. Increases in fishing activities are considered in a separate study of commercial fishing (see **Volume A2, Chapter 6: Commercial Fisheries**).

20.3 Increases in Recreational Vessel Activity

477. There are no known major developments which will increase the activity of recreational vessels within the southern North Sea. As with commercial fishing activity, given the lack of reliable information relating to future trends, a 10% increase is considered conservative.

20.4 Increase in Traffic Associated with Hornsea Four Operations

478. During the construction phase there will be up to 6,126 return trips made by vessels involved in the installation of Hornsea Four (see Section 9.5.1). During the operation and maintenance phase there will be up to 1,433 return trips per year made by vessels involved in the operation and maintenance of Hornsea Four (see Section 9.5.3). Although this traffic will not be considered in the collision and allision risk modelling since mean route positions will not be defined, this traffic has been considered within the hazard log.

20.5 Commercial Traffic Routeing (Hornsea Four in Isolation)

20.5.1 Methodology

479. It is not possible to consider all potential alternative routeing options for commercial traffic and therefore worst case alternatives have been considered where possible in consultation with operators. Assumptions for re-routeing include:

- All alternative routes maintain a minimum mean distance of 1 nm from offshore installations and existing WTG boundaries in line with the MGN 654 Shipping Route Template (MCA, 2021). This distance is considered for shipping and navigation from a safety perspective as explained below;
- All mean routes take into account sandbanks and known routeing preferences; and
- All routes considered as potential users of the gap between Hornsea Four and Hornsea Project Two proceed to utilise the gap.

480. The assumption of a minimum mean distance of 1 nm from offshore installations above is aligned with the policy for DFDS Seaways vessel Masters, which requires that captains "*don't get closer than 1 nm to any ship or platform"*, noting that DFDS Seaways is the prominent vessel operator in the area.

481. MGN 654 provides guidance to offshore renewable energy developers on both the assessment process and design elements associated with the development of an offshore wind farm. Annex 2 of MGN 654 defines a methodology for assessing passing distances between offshore wind farm boundaries (with the minimum distance of 1 nm derived from this) but states that it is "*not a prescriptive tool but needs intelligent application and advice will be provided on a case-by-case-basis*".

482. To date, internal and external studies undertaken by Anatec on behalf of the UK Government and individual clients show that vessels do pass consistently and safely within 1 nm of established offshore wind farms (including between different wind farms) and these distances vary depending upon the sea room available as well as the prevailing conditions. This evidence also demonstrates that the Mariner defines their own safe passing distance based upon the conditions and nature of the traffic at the time, but they are shown to frequently pass 1 nm off established developments. Evidence also demonstrates that commercial vessels do not transit through wind farm arrays. This is all in evidence at the neighbouring Hornsea Project One (operational) and Hornsea Project Two (under construction).

483. The NRA also aims to establish the MDS based on navigational safety parameters, and when considering this the most conservative realistic scenario for vessel routeing is considered to be when main routes pass 1 nm off developments. Evidence collected during numerous assessments at an industry level confirms that it is a safe and reasonable distance for vessels to pass; however, it is likely that a large number of vessels would instead choose to pass at a greater distance

depending upon their own passage plan and the current conditions, as evidenced by the North Shields–Ijmuiden route operated by DFDS Seaways (see Section 16.3).

484. Decisions made regarding re-routeing through the gap between Hornsea Four and Hornsea Project Two are considered conservative, with some vessels on such affected routes likely to pass around the Hornsea Four array area rather than utilise the gap. From consultation, the predominant operator on such affected routes – DFDS Seaways – would utilise the gap and therefore, in line with the need to establish the MDS, all potential gap users have been re-routed through the gap.

20.5.2 Main Route Deviations

485. An illustration of the anticipated shift in the mean positions of the main commercial routes within the Hornsea Four array area shipping and navigation study area following the development of the Hornsea Four array area is presented in Figure 20.1. These deviations are based on Anatec's assessment of the MDS and consultation undertaken with DFDS Seaways which operate vessels on the main routes.

486. Deviations from the pre wind farm scenario would be required for five out of the 14 main routes identified, with the level of deviation varying between 0.4 nm for Route 8 and 5.5 nm for Route 6.

487. For the displaced routes, the increase in distance and percentage change from the pre wind farm scenario is presented in Table 20.1. It is noted that increases in route length are based upon indicative final destinations and percentage changes are based upon the full route length.

Table 20.1 Summary of post wind farm main route deviations within Hornsea Four array area shipping and navigation study area

Route Number	Increase in Route Length (nm)	Increase in Total Route Length (%)
6	5.5	1.5
8	0.4	0.1
10	2.9	0.8
11	1.0	1.0
12	4.6	1.3

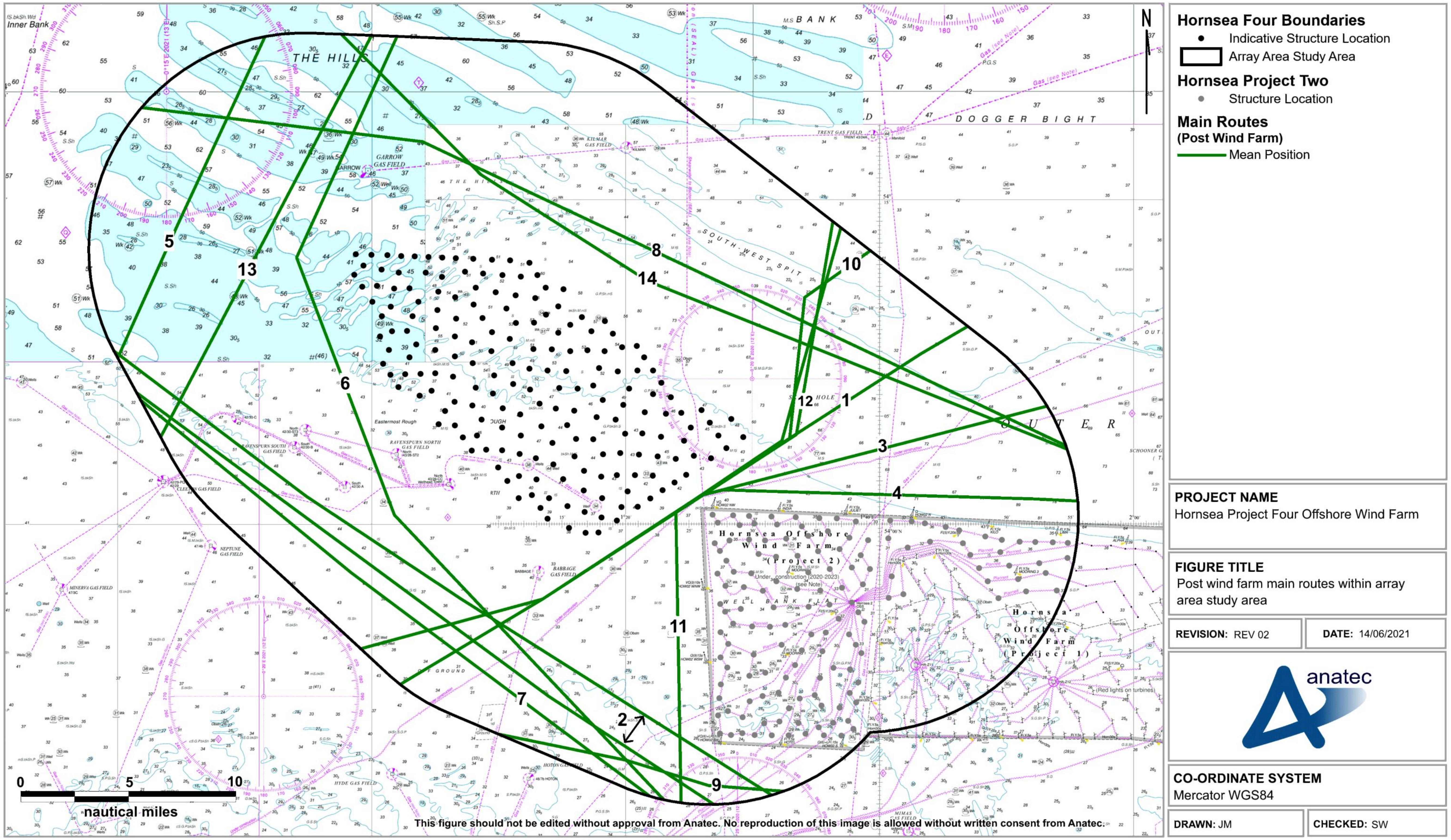
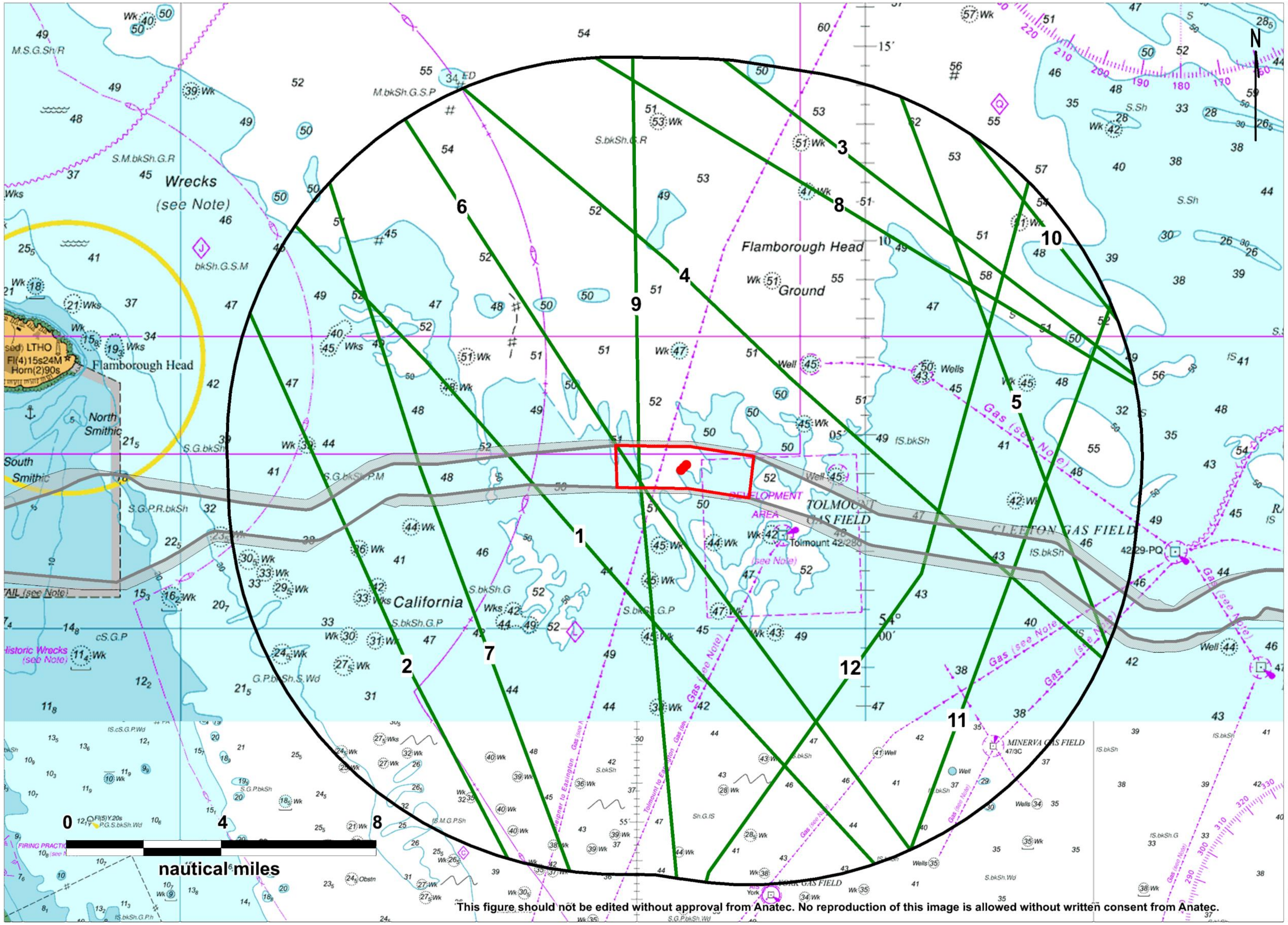


Figure 20.1 Post wind farm main routes within Hornsea Four array area shipping and navigation study area

20.5.2.1 Hornsea Four HVAC Booster Station Search Area

488. An illustration of the anticipated shift in the mean positions of the main commercial routes within the Hornsea Four HVAC booster station search area shipping and navigation study area following the development of the Hornsea Four HVAC booster stations is presented in Figure 20.2.

489. A deviation would be required for two of the 12 main routes identified, with these being deviations of less than 0.1 nm for both Routes 6 and 9, corresponding to a very small change from the pre wind farm scenario. As previously, it is noted that increases in route length are based upon indicative final destinations and percentage changes are based upon the full route length.



Hornsea Four Boundaries
- HVAC Booster Station Search Area
- HVAC Booster Station Search Area Study Area
- Offshore Cable Corridor
- Temporary Working Area
- HVAC Booster Station Location

Main Routes
(Post Wind Farm)
- Mean Position

PROJECT NAME
Hornsea Project Four Offshore Wind Farm

FIGURE TITLE
Post wind farm routes within HVAC booster station study area

REVISION: REV 00 | **DATE:** 14/06/2021

anatec

CO-ORDINATE SYSTEM
Mercator WGS84

DRAWN: JM | **CHECKED:** SW

Figure 20.2 Post wind farm main routes within Hornsea Four HVAC booster station search area shipping and navigation study area

20.6 Commercial Traffic Routeing (Cumulative)

20.6.1 Methodology

490. The same methodology outlined for the main route deviations for Hornsea Four in isolation (see Section 20.5.1) has been considered at the cumulative level. The assumptions for re-routeing have been applied to all screened in developments and projects (see Section 19.1).

20.6.2 Main Route Deviations

20.6.2.1 Hornsea Four Array Area

491. An illustration of the anticipated shift in the mean positions of the main commercial routes within the Hornsea Four cumulative shipping and navigation study area following the development of the Hornsea Four array area and CEA projects is presented in Figure 20.3. These deviations are based on Anatec's assessment of the MDS and consultation undertaken with DFDS Seaways who operate vessels on the main routes.

492. Compared to the pre wind farm scenario, deviations would be required for seven out of the 14 main routes identified, with the level of deviation varying between a 1.3 nm decrease for Route 8 (due to the route being anticipated to utilise the navigational corridor between Hornsea Project One, Hornsea Project Two and Hornsea Three) and 6.7 nm for Route 4.

493. For the displaced routes, the increase in distance and percentage change from the pre wind farm scenario is presented in Table 20.2. As previously, it is noted that increases in route length are based upon indicative final destinations and percentage changes are based upon the full route length.

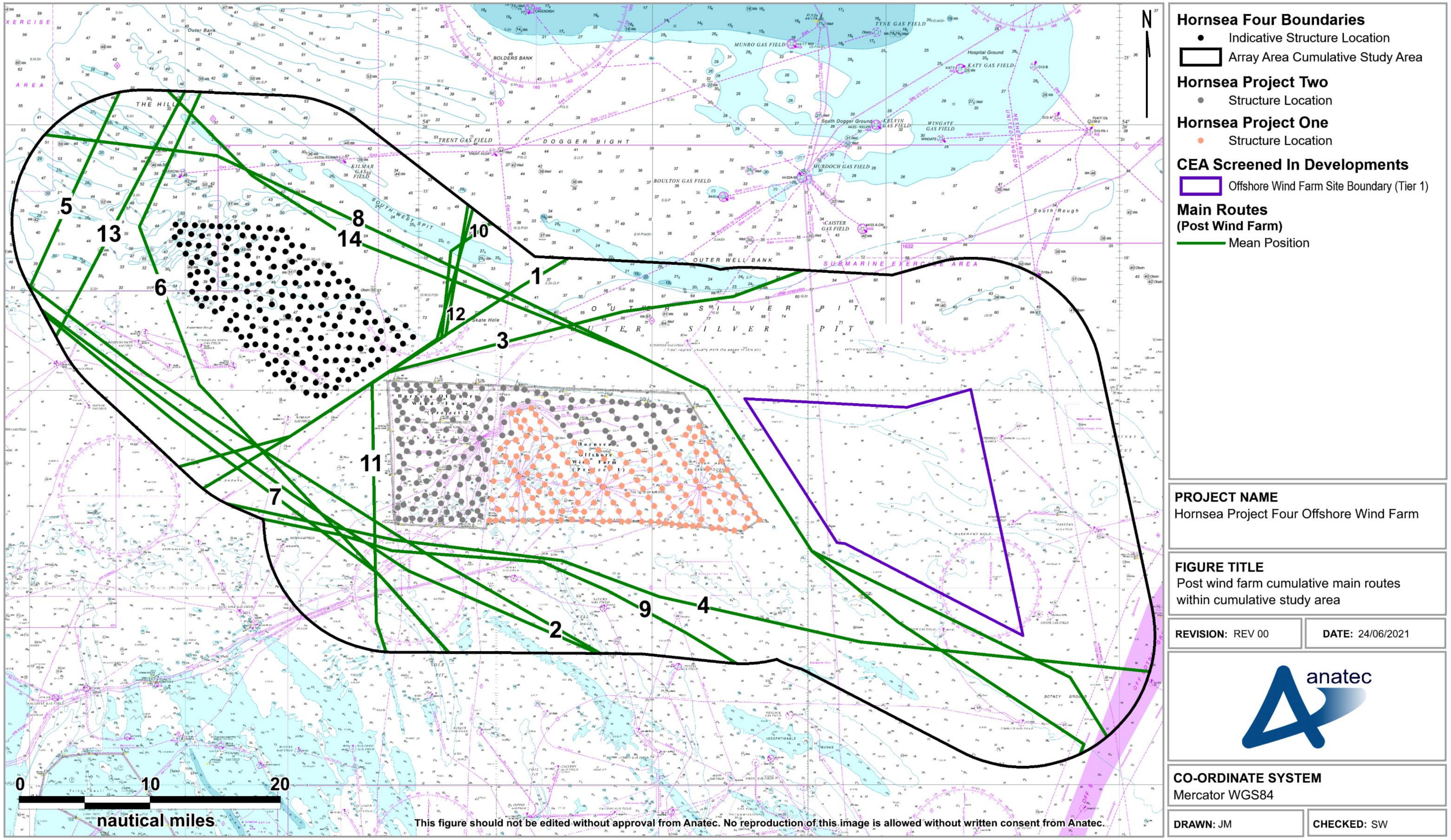


Figure 20.3 Post wind farm cumulative main routes within Hornsea Four cumulative shipping and navigation study area

Table 20.2 Summary of post wind farm main route deviations within Hornsea Four cumulative array area shipping and navigation study area

Route Number	Increase in Route Length (nm)	Increase in Total Route Length (%)
4	6.7	2.1
6	5.4	1.5
8	-4.2	-1.3
10	2.9	0.8
11	1.0	1.0
12	4.6	1.3
14	1.1	0.7

20.6.2.2 Hornsea Four HVAC Booster Station Search Area

494. As noted in Section 19.2.2, there are no CEA developments in proximity to the HVAC booster station search area (the nearest CEA development is the Tier 3 Endurance carbon capture and storage project located approximately 15 nm from the HVAC booster station search area). Therefore, deviations at the cumulative level due to the presence of the HVAC booster stations are considered to be analogous to those determined for the assessment of Hornsea Four in isolation.

21 Collision and Allision Risk Modelling

21.1 Overview

495. To inform the impact assessment, a quantitative assessment of the major hazards associated with Hornsea Four has been undertaken. The following subsections outline the inputs and methodology used for the collision and allision risk modelling, noting that allision risk associated with oil and gas infrastructure is considered in Appendix C of **Volume A5, Annex 11.1: Offshore Installation Interfaces**.

21.1.1 Scenarios Under Consideration

496. For each element of the quantitative assessment both a pre and post wind farm scenario with base and future case vessel traffic levels have been considered. As a result, four distinct scenarios have been modelled:

1. Pre wind farm with base case vessel traffic levels;
2. Pre wind farm with future case vessel traffic levels;
3. Post wind farm with base case vessel traffic levels; and
4. Post wind farm with future case vessel traffic levels.

21.1.2 Hazards Under Consideration

497. Hazards considered in the quantitative assessment are as follows:

- Increased vessel to vessel collision risk;
- Increased powered vessel to structure allision risk;
- Increased drifting vessel to structure allision risk; and
- Increased fishing vessel to structure allision risk.

498. The pre wind farm assessment has used the vessel traffic survey data (see Section 15) in combination with the outputs of consultation (see Section 14) and other baseline data sources (such as Anatec's ShipRoutes database and previous NRAs undertaken within the Former Hornsea Zone). Conservative assumptions have then been made with regard to route deviations and future shipping growth over the life of Hornsea Four.

21.1.3 Post Wind Farm Routeing

499. The methodology applied for determining post wind farm routeing is outlined in Section 20.5.1.

21.2 Hornsea Four Array Area Modelling

21.2.1 Pre Wind Farm

21.2.1.1 Vessel to Vessel Encounters

500. An assessment of current vessel to vessel encounters in proximity to the Hornsea Four array area has been undertaken by replaying at high speed the data collected as part of the vessel traffic surveys (see Section 15.1).

501. The model defines an encounter as two vessels passing within 1 nm of each another within the same minute. This helps to illustrate where existing shipping congestion is highest and therefore where offshore developments, such as an offshore wind farm, could potentially increase congestion and therefore also increase the risk of encounters and collisions. No account has been given as to whether the encounters are head on or stern to head; just close proximity.

502. A heat map based upon the geographical distribution of vessel encounter tracks within a 0.5×0.5 nm grid is presented in Figure 21.1. Following this, Figure 21.2 and Figure 21.3 illustrate the daily number of encounters recorded within the Hornsea Four array area shipping and navigation study area throughout the summer and winter survey periods, respectively.

503. There was an average of nine encounters per day within the Hornsea Four array area shipping and navigation study area throughout the survey periods. The day with the greatest number of encounters within the Hornsea Four array area shipping and navigation study area was 1st August 2020 when 20 encounters were recorded.

504. The majority of encounters occurred in proximity to the surface platforms located in the Ravenspurn and Babbage gas fields. Encounters were also observed at the southern boundary of the Hornsea Four array area where commercial traffic passes around the under construction Hornsea Project Two; such traffic is further considered in Section 19.3.2.

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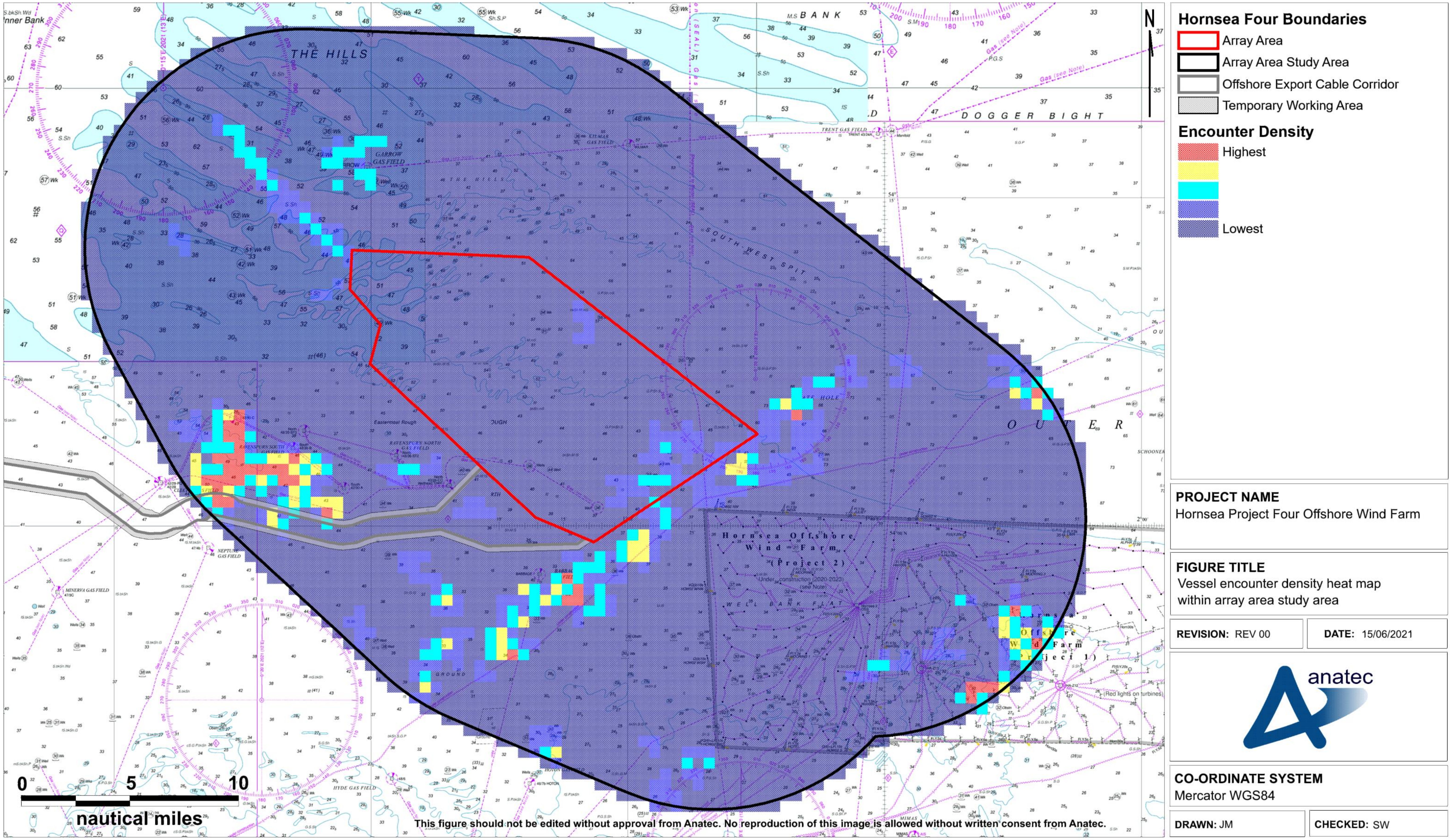

Figure 21.1 Vessel encounters heat map within Hornsea Four array area shipping and navigation study area

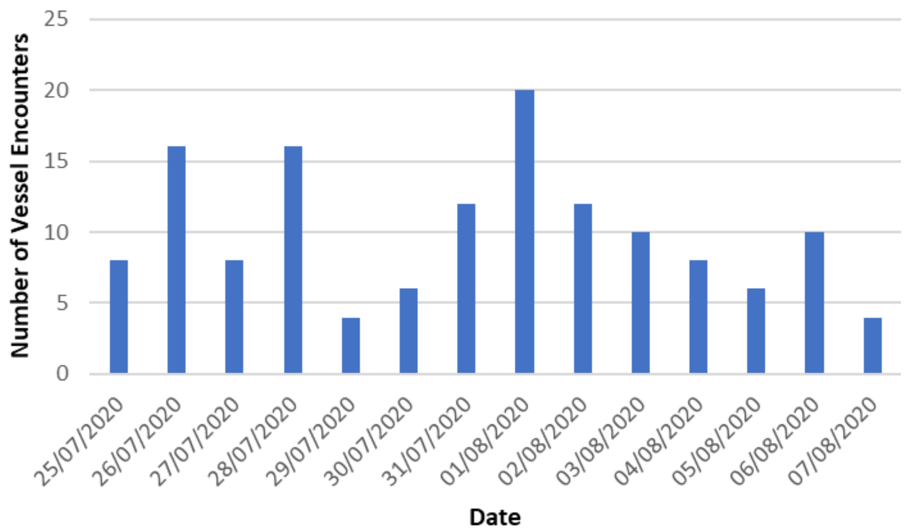

Figure 21.2 Vessel encounters per day within Hornsea Four array area and shipping and navigation study area (14 days summer 2020)

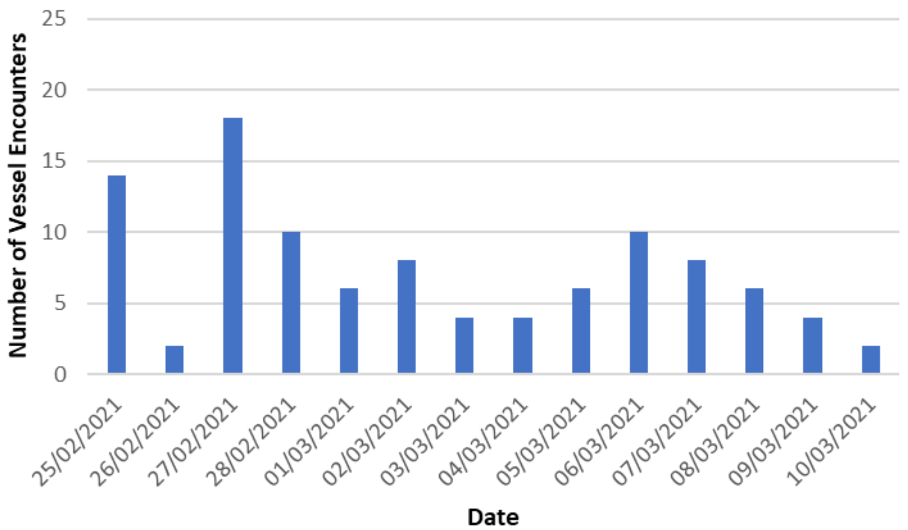

Figure 21.3 Vessel encounters per day within Hornsea Four array area and shipping and navigation study area (14 days winter 2021)

505. The distribution of the main vessel types involved in encounters within the Hornsea Four array area shipping and navigation study area is presented in Figure 21.4

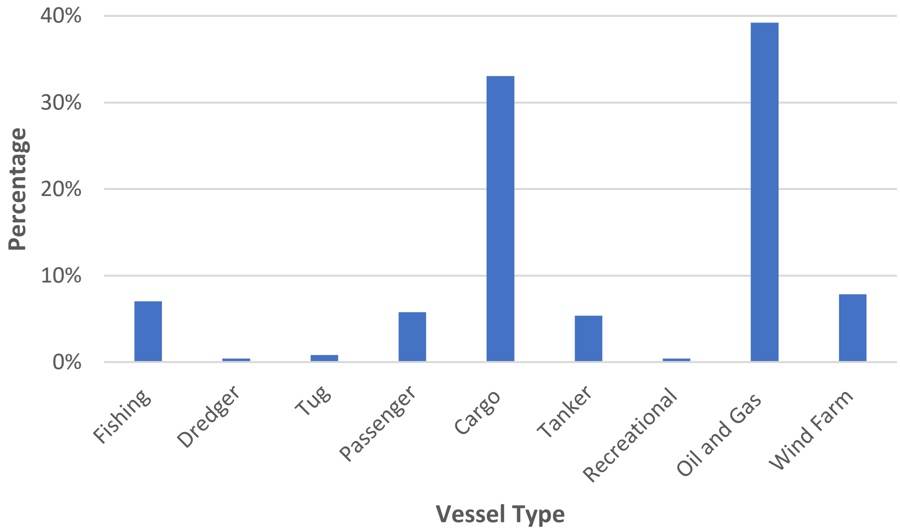

Figure 21.4 Distribution of encounter vessel types within Hornsea Four array area shipping and navigation study area

506. The most frequent vessel types involved in encounters were oil and gas vessels (39%) owing to the presence of a number of non-transient support vessels for the oil and gas installations in the region (see Section 15.1.2.3). A significant proportion of the vessel types involved in encounters were also cargo vessels (33%) with the majority of these encounters occurring at the southern boundary of Hornsea Four where commercial traffic passes around the under construction Hornsea Project Two (Section 19.3.2).

21.2.1.2 Vessel to Vessel Collisions

507. Using the pre wind farm vessel routeing (see Section 15.1.5) as input, Anatec's COLLRISK model has been run to estimate the existing vessel to vessel collision risk in proximity to the Hornsea Four array area. The route positions and widths are based upon the vessel traffic survey data, with the annual densities based upon port logs and Anatec's ShipRoutes database, which takes seasonal variations into consideration.

508. A heat map based upon the geographical distribution of collision risk within a 0.5×0.5 nm grid for the base case is presented in Figure 21.5.

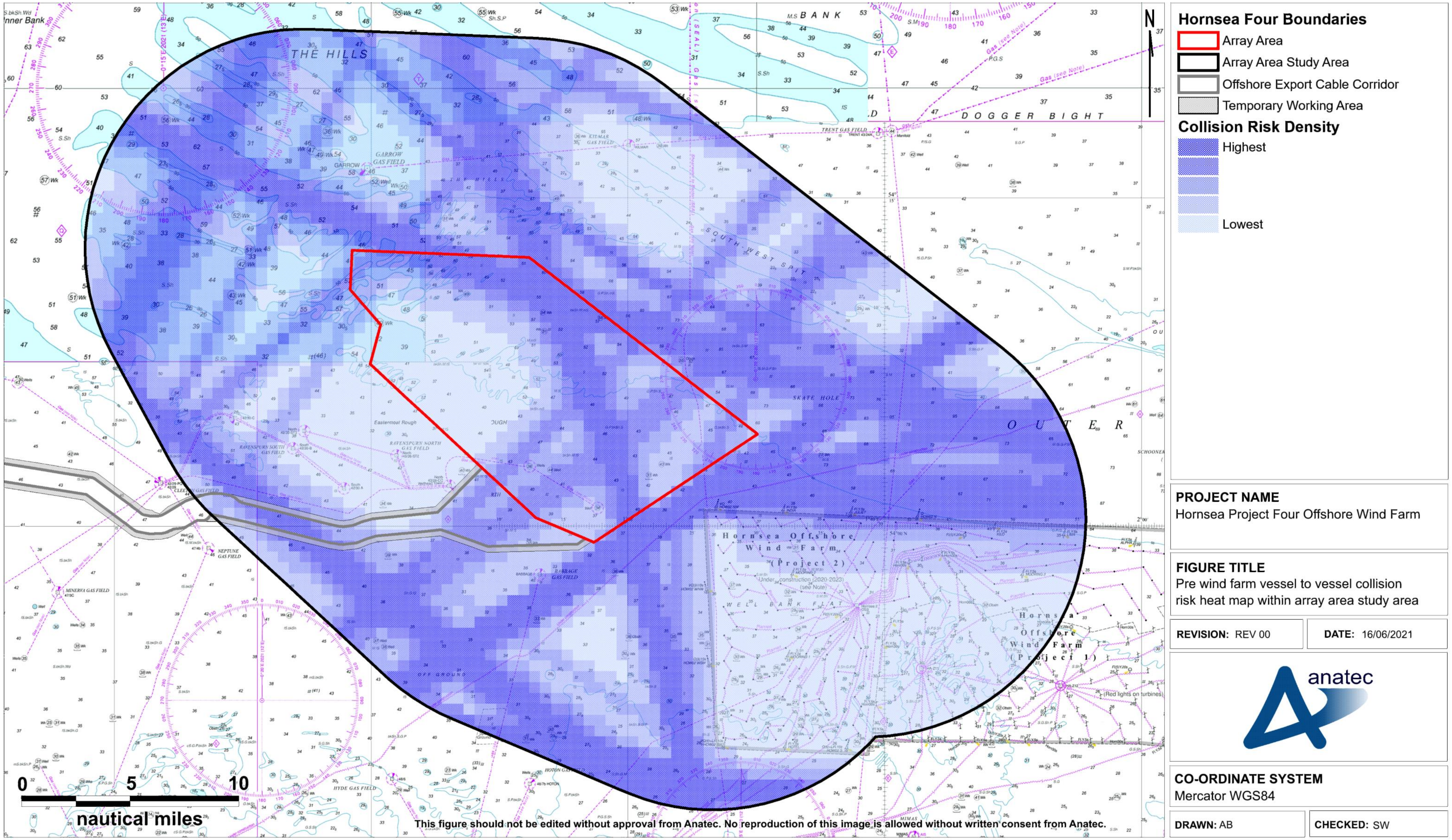

Figure 21.5 Pre wind farm vessel to vessel collision risk heat map for base case within Hornsea Four array area shipping and navigation study area

509. Assuming base case vessel traffic levels, the annual collision frequency pre wind farm was estimated to be 5.81×10^{-3}, corresponding to a collision return period of approximately one in 172 years. Compared to assessments undertaken for other sea areas with proposed offshore wind farm developments this is a relatively high background vessel to vessel collision risk level and can be attributed to the presence of a number of main routes which are transited on a daily basis and which are primarily concentrated towards the southern section of the Hornsea Four array area where the construction of Hornsea Project Two reduces the available sea room.

510. It is noted that the model is calibrated based upon major incident data at sea which allows for benchmarking but does not cover all incidents, such as minor impacts. Other incident data, which includes reported minor incidents, is presented in Section 13.

21.2.2 Post Wind Farm

511. For clarity, where applicable figures presenting post wind farm modelling results show only those wind farms structures located within the Hornsea Four array area shipping and navigation study area noting that some Hornsea Project Two structures are outside of this study area. However, the quantitative results (frequency and return periods) for these hazards are inclusive of all Hornsea Four and Hornsea Project Two structures.

21.2.2.1 Simulated Automatic Identification System

512. Anatec's AIS Simulator software was used to gain an insight into the potential re-routed traffic following the installation of wind farm structures within the Hornsea Four array area. The AIS Simulator uses the mean positions of identified routes within the Hornsea Four array area shipping and navigation study area and the anticipated shift post wind farm, along with the standard deviations and average number of vessels on each route to simulate the tracks. It is noted that fishing vessels and recreational vessels are not included in the identified main routes given the less stringent AIS carriage requirements for such vessels and the lack of routeing trends, and therefore are excluded from the simulation.

513. A plot of 28 days of simulated AIS within the Hornsea Four array area shipping and navigation study area based upon the deviated main routes is presented in Figure 21.6.

514. It is noted that the simulated AIS represents an MDS based upon a mean 1 nm passing distance from both the Hornsea Four and Hornsea Project Two array areas for passing routes. The MDS also assumes the maximum number of potential transits through the gap between Hornsea Four and Hornsea Project Two; it is possible that some of the routeing vessels currently anticipated to pass through the gap will choose not to do so. Furthermore, as assessed in Section 19.3.3, the

likelihood of multiple vessels transiting through the gap simultaneously and therefore experiencing an encounter is low.

21.2.2.2 Vessel to Vessel Collisions

515. Using the post wind farm routeing as an input, Anatec's COLLRISK model was run to estimate the vessel to vessel collision risk in proximity to the Hornsea Four array area.

516. A heat map based upon the geographical distribution of collision risk within a 0.5×0.5 nm grid for the base case is presented in Figure 21.7.

517. Assuming base case vessel traffic levels, the annual collision frequency post wind farm was estimated to be 6.64×10^{-3}, corresponding to a collision return period of approximately one in 151 years. This represents a 14% increase in collision frequency compared to the base case pre wind farm result. Results for the future cases (pre and post wind farm) are included in Table 21.1.

518. The increase in vessel to vessel collision risk was greatest within and in proximity to the gap between Hornsea Four and Hornsea Project Two. Further analysis of the likelihood of a vessel encounter within the gap between Hornsea Four and Hornsea Project Two is presented in Section 19.3.3.

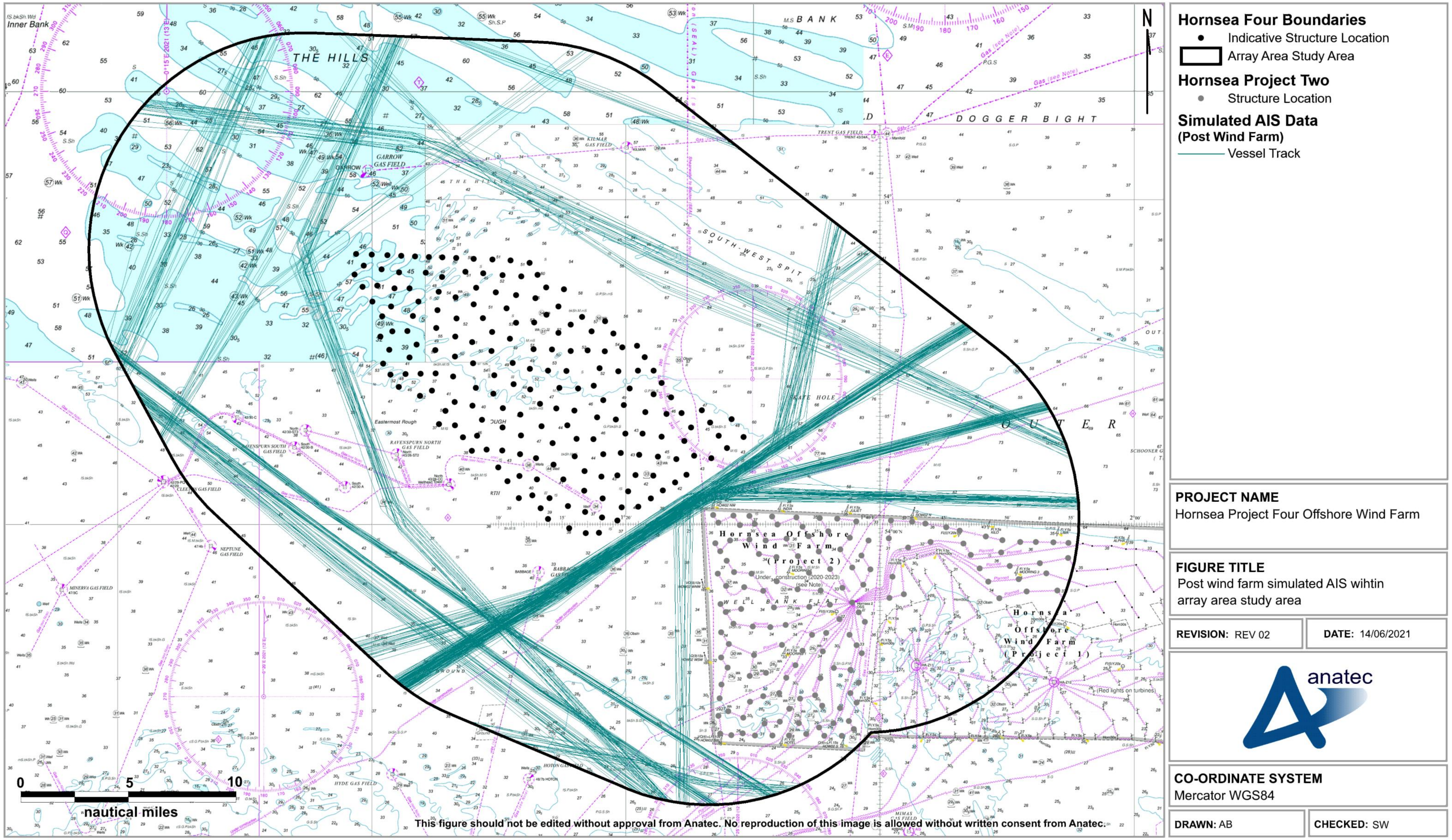

Figure 21.6 Post wind farm simulated AIS tracks for base case within Hornsea Four array area shipping and navigation study area (28 days)

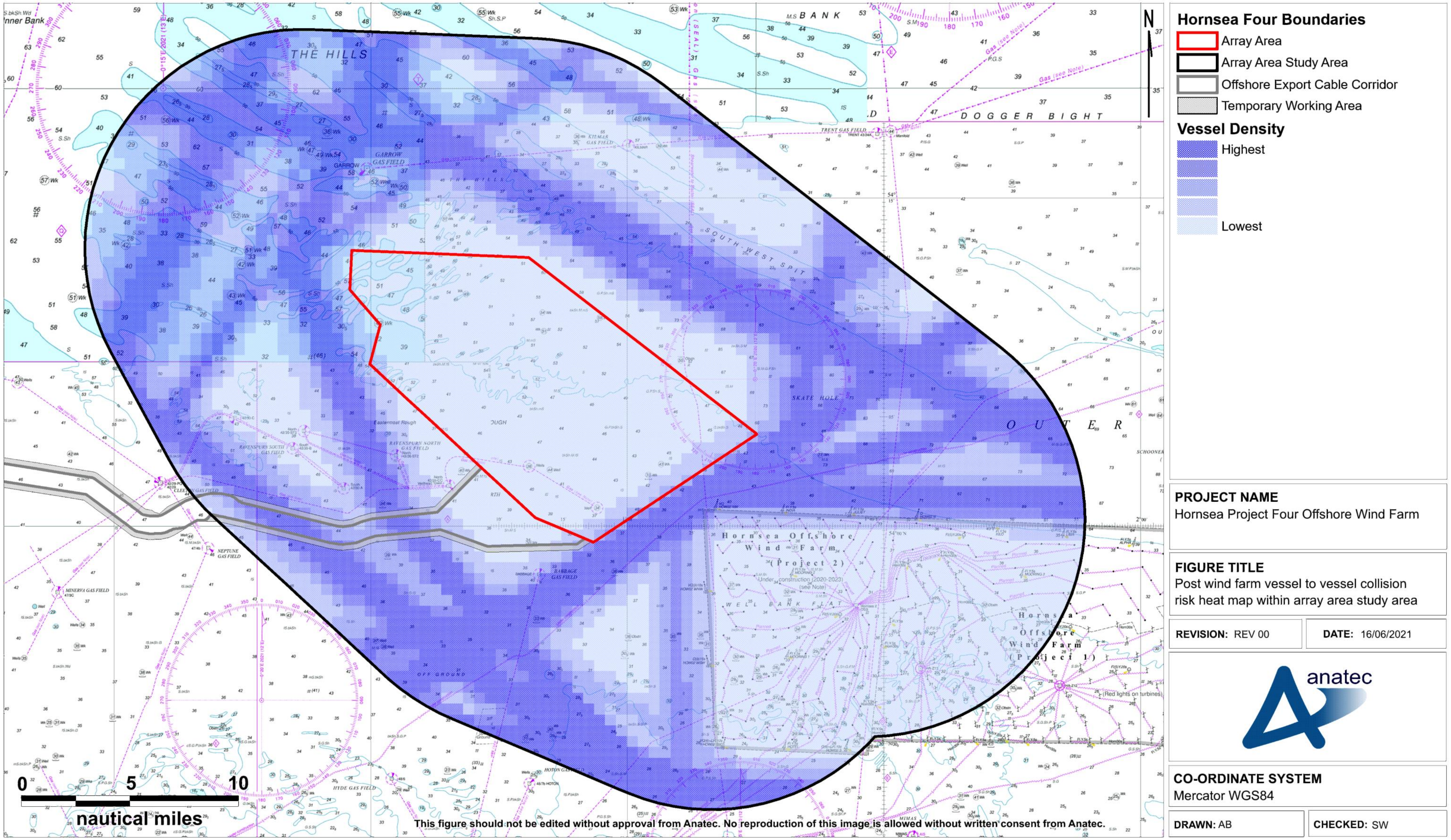

Figure 21.7 Post wind farm vessel to vessel collision risk heat map for base case within Hornsea Four array area shipping and navigation study area

21.2.2.3 Powered Vessel to Hornsea Four and Hornsea Project Two Structure Allision

519. Based upon the vessel routeing identified in the region, the anticipated change in routeing due to the Hornsea Four array area, and assumptions that commitments included as part of Hornsea Four 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 Hornsea Four or Hornsea Project Two structure is considered to be low.

520. From consultation with the shipping industry it is also assumed that commercial vessels would be highly unlikely to navigate between wind farm structures due to the restricted sea room and will instead be directed by the aids to navigation located in the region. During the construction and decommissioning phases this will primarily consist of the buoyed construction area whilst during the operation and maintenance phase this will primarily consist of the lighting and marking of the wind farm structures themselves.

521. Using the post wind farm routeing as an input, alongside the array layout and local Metocean data, Anatec's COLLRISK model was run to estimate the likelihood of a commercial vessel alliding with one of the wind farm structures within the Hornsea Four or Hornsea Project Two array areas whilst under power. To maintain the need to assess an MDS, the model did not take into account the possibility of one structure shielding another.

522. A plot of the annual powered allision frequency per structure for the base case is presented in Figure 21.8, with the chart background removed to increase the visibility of those structures with a low allision frequency.

523. Assuming base case vessel traffic levels, the annual powered allision frequency post wind farm was estimated to be 1.08×10^{-3}, corresponding to an allision return period of approximately one in 929 years. Results for the future case are included in Table 21.1.

524. The greatest powered vessel to structure allision risk was associated with structures on the southern boundary of Hornsea Four and northern boundary of Hornsea Project Two where multiple routes are deviated through the gap between Hornsea Four and Hornsea Project Two. There was also a higher allision risk associated with the structures on the north west and north east corners of Hornsea Four where routes are deviated to pass a minimum of 1 nm from the array area. The highest individual allision risk was associated with the structure on the south east corner of the Hornsea Four array area (approximately 1.86×10^{-4} or one in approximately 5,400 years) where multiple routes pass with a closest point of approach (CPA) of 1 nm when entering or exiting the gap.

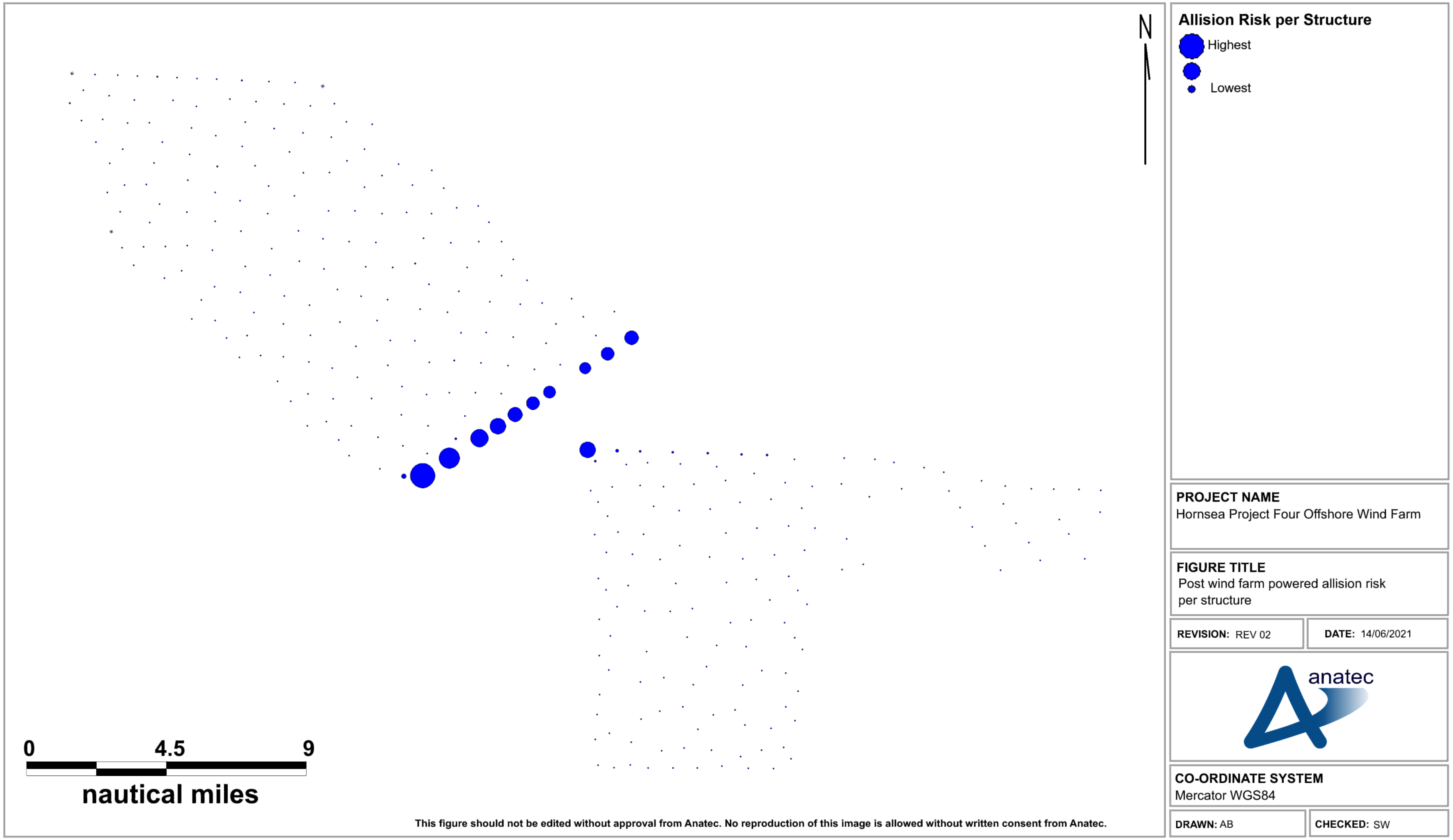

Figure 21.8 Post wind farm vessel to Hornsea Four and Hornsea Project Two structure powered allision risk per structure for base case for Hornsea Four array area

21.2.2.4 Drifting Vessel to Hornsea Four and Hornsea Project Two Structure Allision

525. Using the post wind farm routeing as input, alongside the array layout and local Metocean data, Anatec's COLLRISK model was run to estimate the likelihood of a drifting commercial vessel alliding with one of the wind farm structures within the Hornsea Four or Hornsea Project Two array areas. The model is based on the premise that propulsion on a vessel must fail before drifting will occur. The model takes account of the type and size of the vessel, the number of engines and the average time required to repair but does not consider navigational error caused by human actions.

526. The exposure times for a drifting scenario are based upon the vessel hours spent in proximity to the Hornsea Four and Hornsea Project Two array areas (up to 10 nm from the array areas). These have been estimated based upon the vessel traffic levels, speeds and revised routeing pattern. The exposure is divided by vessel type and size to ensure these factors, which based upon analysis of historical incident data have been shown to influence incident rates, are taken into account within the modelling.

527. Using this information, the overall rate of mechanical failure within proximity to the Hornsea Four and Hornsea Project Two array areas was estimated. The probability of a vessel drifting towards a wind farm structure and the drift speed are dependent upon the prevailing wind, wave, and tidal conditions at the time of the incident. Therefore, three drift scenarios were modelled, each using the Metocean data provided in Section 11:

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

528. The probability of vessel recovery from drift is estimated based upon the speed of drift and hence the time available before reaching the wind farm structure. Vessels which do not recover within this time are assumed to allide.

529. After modelling the drift scenarios, it was established that the ebb tide dominated scenario produced the worst case results. A plot of the annual powered allision frequency per structure for the base case is presented in Figure 21.9, with the chart background removed to increase the visibility of those structures with a low allision frequency.

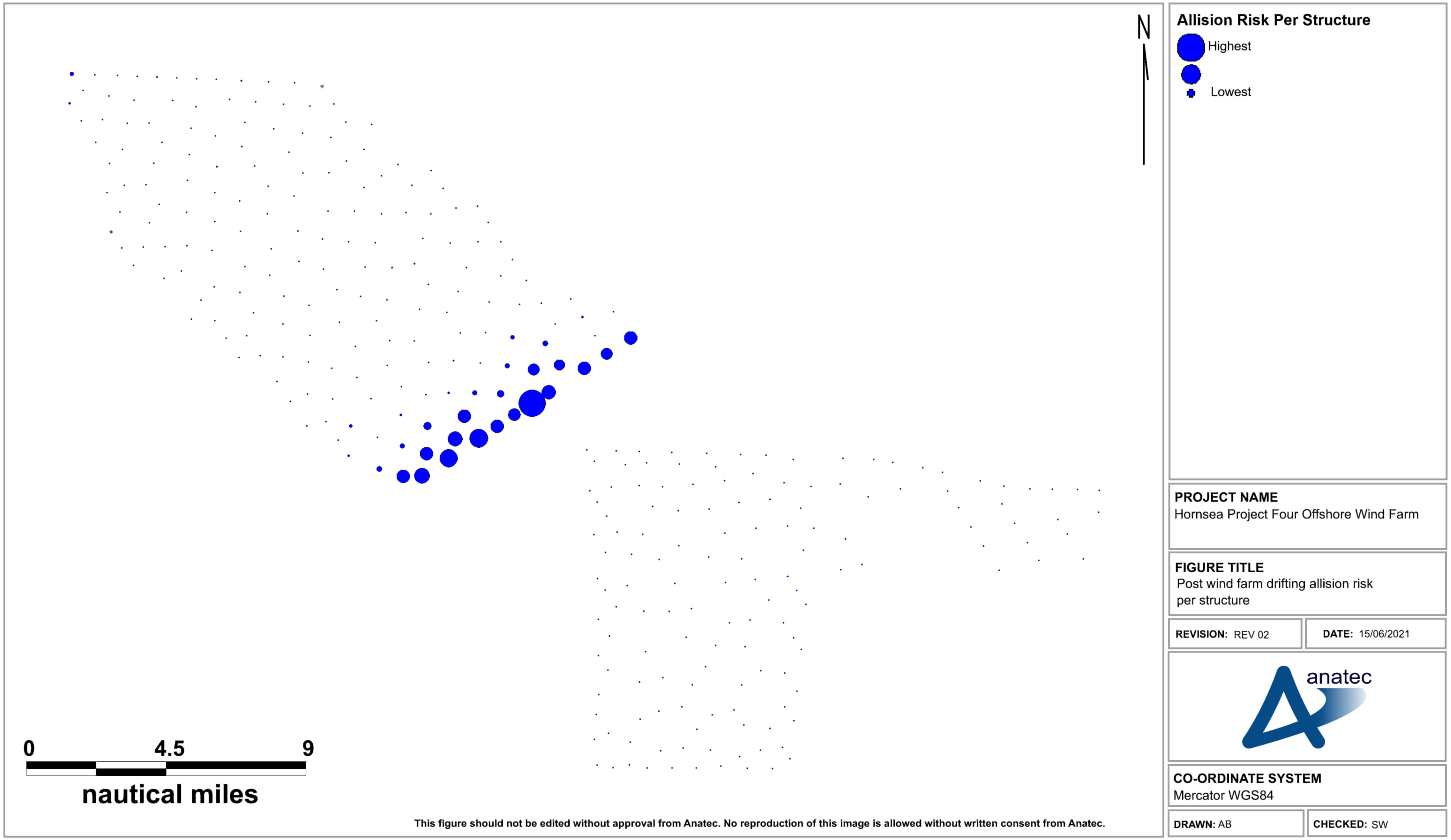

Figure 21.9 Post wind farm vessel to Hornsea Four and Hornsea Project Two structure drifting allision risk per structure for base case for Hornsea Four array area

530. Assuming base case vessel traffic levels, the annual drifting allision frequency post wind farm was estimated to be 1.16×10^{-3}, corresponding to an allision return period of approximately one in 866 years. Results for the future case are included in Table 21.1.

531. The highest drifting vessel to structure allision risk was associated with structures on the southern boundary of Hornsea Four where multiple routes are deviated through the gap between Hornsea Four and Hornsea Project Two and the peak spring ebb tidal direction is towards the Hornsea Four array area. The highest individual allision risk was associated with the structure on the southern boundary of the Hornsea Four array area at the narrowest point of the gap (approximately 1.82×10^{-4} or one in 5,480 years) where multiple routes pass with a CPA of 1 nm through the gap.

532. It is noted that historically there have been no reported drifting allision incidents with wind farm structures in the UK. Whilst drifting vessels do occur every year in UK waters, in most cases the vessel has been recovered prior to any allision incident occurring (such as by anchoring, restarting engines or being taken in tow).

21.2.2.5 Fishing Vessel to Structure Allision

533. Using the AIS and Radar data as input[5] (see Section 15.1.8.1 and Appendix E), alongside the array layout (including structure dimensions), Anatec's COLLRISK fishing risk model was run to estimate the likelihood of a fishing vessel alliding with one of the wind farm structures within the Hornsea Four array area. The 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 United Kingdom Continental Shelf (UKCS) offshore installations published by the UK HSE.

534. Assuming base case traffic levels, the annual fishing vessel to structure allision frequency post wind farm was estimated to be 4.51×10^{-2}, corresponding to an allision return period of approximately one in 22 years. Results for the future case are included in Table 21.1.

535. This is considered a relatively low level of allision frequency for fishing vessels when compared with results for other offshore wind farm developments around the UK and reflects the relatively low level of fishing vessel activity in the region. It is noted that the model assumes that the fishing vessel density remains the same as at pre wind farm levels and therefore is considered a conservative estimate. In reality vessel activity would likely decrease as well as be affected by seasonal and annual

[5] To assist with the accuracy of the outputs of Anatec's COLLRISK fishing risk model, all vessel traffic survey data collected for the Hornsea Four array area has been used as input. This includes not only the 2020/21 vessel traffic survey data (for which the 14 days in winter 2021 includes Radar) but also the 2019 vessel traffic survey data (for which all 28 days include Radar).

fluctuations. The model also does not evaluate the severity of the allision which may be of low energy and low impact.

21.2.3 Risk Results Summary

536. The previous sections modelled two scenarios, namely the pre and post wind farm scenarios each with base case traffic levels. In order to incorporate the potential for future traffic growth pre and post wind farm scenarios each with future case traffic levels have also been modelled. Table 21.1 summarises the results of all four scenarios.

Table 21.1 Summary of annual collision and allision risk results for Hornsea Four array area

Collision/ Allision Scenario	Base Case			Future Case		
	Pre Wind Farm	Post Wind Farm	Change	Pre Wind Farm	Post Wind Farm	Change
Vessel to vessel collision	5.81×10^{-3} (1 in 172 years)	6.64×10^{-3} (1 in 151 years)	8.35×10^{-4} (1 in 151 years)	7.04×10^{-3} (1 in 142 years)	8.06×10^{-3} (1 in 124 years)	1.01×10^{-3} (1 in 987 years)
Powered vessel to structure allision	N/A	1.08×10^{-3} (1 in 929 years)	1.08×10^{-3} (1 in 929 years)	N/A	1.19×10^{-3} (1 in 843 years)	1.19×10^{-3} (1 in 843 years)
Drifting vessel to structure allision	N/A	1.16×10^{-3} (1 in 866 years)	1.16×10^{-3} (1 in 866 years)	N/A	1.27×10^{-3} (1 in 785 years)	1.27×10^{-3} (1 in 785 years)
Fishing vessel to structure allision	N/A	4.51×10^{-2} (1 in 22 years)	4.51×10^{-2} (1 in 22 years)	N/A	4.96×10^{-2} (1 in 21 years)	4.96×10^{-2} (1 in 21 years)
Total	**5.81×10^{-3} (1 in 172 years)**	**5.40×10^{-2} (1 in 19 years)**	**4.82×10^{-2} (1 in 21 years)**	**7.04×10^{-3} (1 in 142 years)**	**6.01×10^{-2} (1 in 17 years)**	**5.31×10^{-2} (1 in 19 years)**

537. Overall, the collision and allision frequency for the Hornsea Four array area was estimated to increase by approximately 4.82×10^{-2} (one incident in 21 years) for the base case and 5.31×10^{-2} (one incident in 19 years) for the future case.

21.2.4 Consequences

538. The most likely consequences for the majority of hazards associated with shipping and navigation are anticipated to be minor in nature, e.g. glancing blow or minor bump. However, the worst case consequences may be severe, including incidents with Potential Loss of Life (PLL).

539. For larger commercial vessels, a powered allision incident would be more likely to result in the collapse of a wind farm structure than any material damage to the vessel itself. For such larger vessels, the breach of a fuel tank is considered unlikely given the robustness of the vessel and in the case of vessels carrying cargoes which may be deemed to be hazardous (e.g. tankers or gas carriers) the additional safety features associated with these vessels would further mitigate the risk of pollution (e.g. double hulls). Similarly, in a drifting allision incident the wind farm structure would likely absorb the majority of the impact energy, particularly given the likely low speed of the errant vessel and the allision energy deflected by the movement of the vessel.

540. For smaller vessels, such as fishing vessels and recreational vessels, the worst case consequences would be the risk of vessel damage leading to foundering of the vessel and potential for personnel in the water and PLL.

541. A quantitative assessment of the potential consequences of a collision or allision incident is provided in Appendix A. This assessment applies the modelling results presented in this section to historical data regarding collision and allision incidents and oil pollution. The following paragraphs summarise the output of the assessment.

542. The overall annual increase in PLL estimated due to the impact of Hornsea Four on passing vessels for the base case is approximately 2.67×10^{-3}, corresponding to one additional fatality in approximately 421 years. In terms of individual risk to people, the incremental increase estimated due to the impact of Hornsea Four for the base case is 7.89×10^{-5}, corresponding to one additional individual fatality in approximately 12,600 years.

543. Based upon the collision and allision frequencies and historical oil spill data, the overall increase in oil spilled due to Hornsea Four is estimated to be 0.46 tonnes of oil per year for the base case. From research undertaken as part of the *Identification of Marine Environmental High Risk Areas (MEHRAs) in the UK* (DfT, 2001) the average annual tonnes of oil spilled in the waters around the British Isles due to marine incidents in the 10-year period from 1989 to 1998 was 16,111. Therefore, the overall increase in pollution estimated for Hornsea Four represents a very low increase compared to the current average annual tonnes of oil spilled and hence can be considered minimal in comparison to the annual average.

544. On this basis, the incremental increase in risk to both people and the environment caused by Hornsea Four is estimated to be very low.

21.3 Hornsea Four HVAC Booster Station Modelling

21.3.1 Pre Wind Farm

21.3.1.1 Vessel to Vessel Encounters

545. An assessment of current vessel to vessel encounters within and in proximity to the Hornsea Four HVAC booster station search area has been undertaken by replaying at high speed the data collected as part of the vessel traffic surveys (see Section 15.3). The methodology used to identify encounters is outlined in Section 21.2.

546. A heat map based upon the geographical distribution of vessel encounter tracks within a 0.5×0.5 nm grid is presented in Figure 21.10. Figure 21.11 and Figure 21.12 illustrate the daily number of encounters recorded within the Hornsea Four HVAC booster station search area shipping and navigation study area throughout the survey periods.

547. There was an average of 25 encounters per day within the Hornsea Four HVAC booster station search area shipping and navigation study area throughout the survey periods. The day with the greatest number of encounters within the Hornsea Four HVAC booster station search area shipping and navigation study area was 21st March 2021 when 56 encounters were recorded.

548. The majority of encounters occurred in the western and southern sections of the Hornsea Four HVAC booster station search area shipping and navigation study area where a number of heavily trafficked main routes follow the UK east coast. There was also a higher encounter density east of the Hornsea Four HVAC booster station search area where work relating to the Tolmount field was being undertaken mostly during the winter survey period.

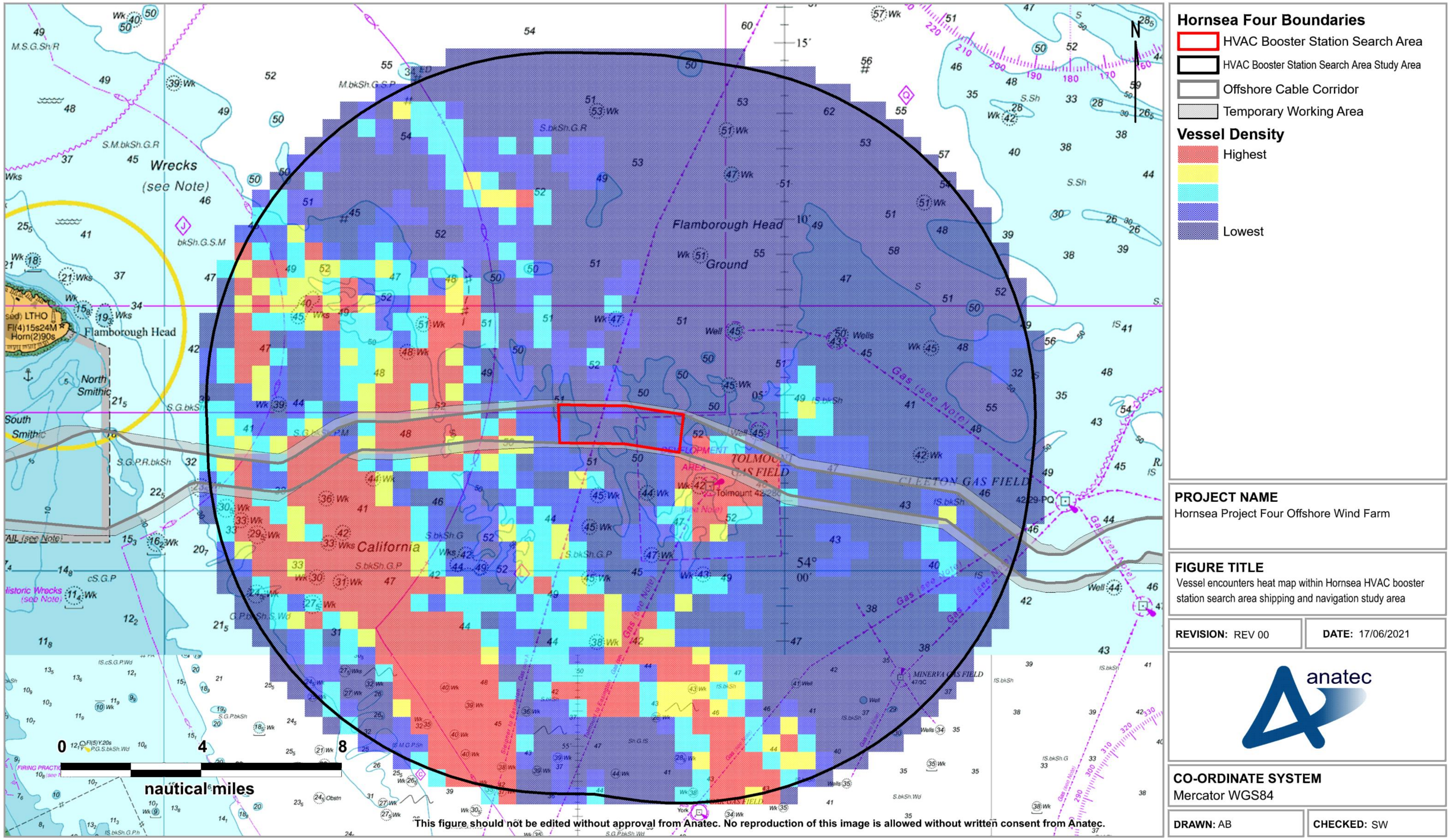

Figure 21.10 Vessel encounters heat map within Hornsea Four HVAC booster station search area shipping and navigation study area

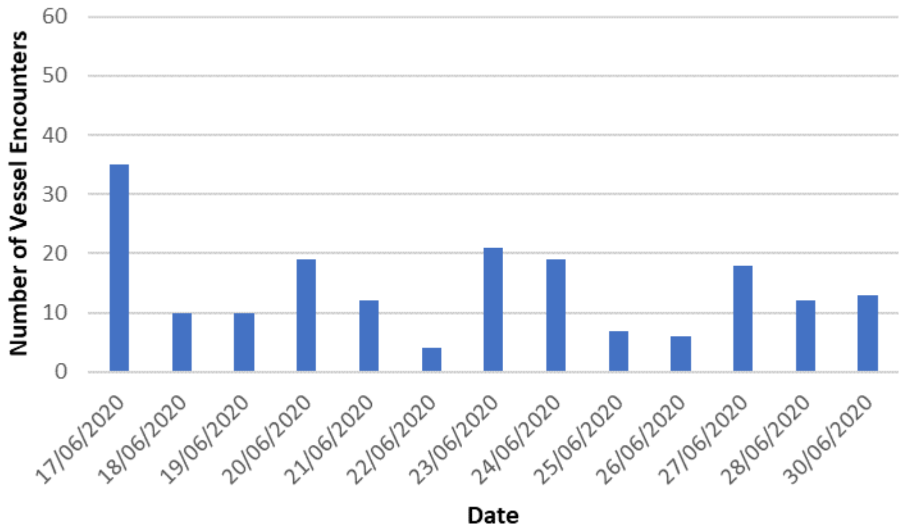

Figure 21.11 Vessel encounters per day within Hornsea Four HVAC booster station search area and shipping and navigation study area (summer 2020)

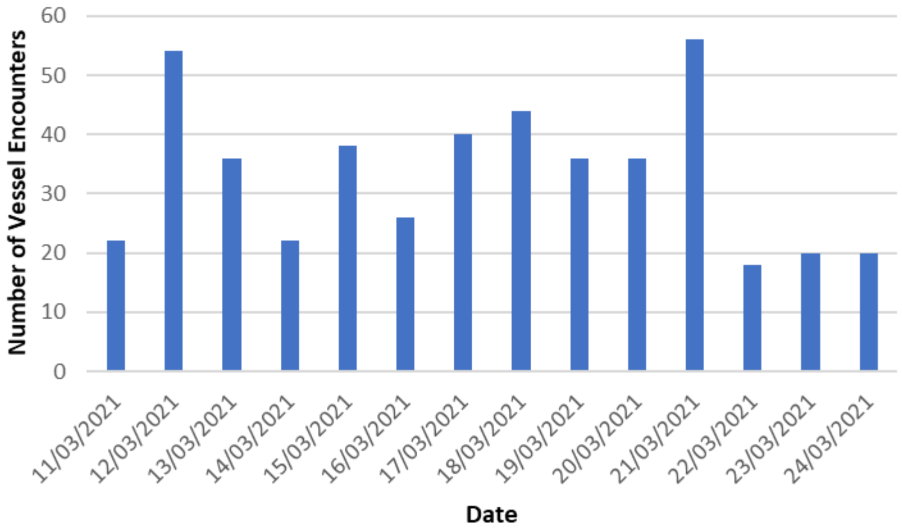

Figure 21.12 Vessel encounters per day within Hornsea Four HVAC booster station search area and shipping and navigation study area (winter 2021)

549. The distribution of the main vessel types involved in encounters within the Hornsea Four HVAC booster station search area shipping and navigation study area is presented in Figure 21.13.

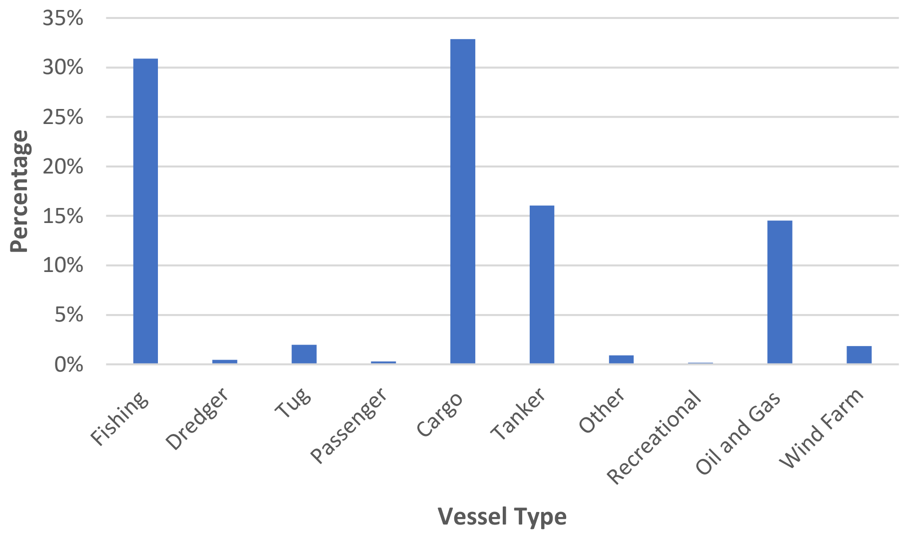

Figure 21.13 Distribution of encounter vessel types within Hornsea Four HVAC booster station search area shipping and navigation study area

550. The most frequent vessel types involved in encounters were cargo vessels (33%) followed by fishing vessels (31%), with this due to the high volume of cargo vessels making transit along the UK east coast and the extended duration of fishing vessel presence whilst engaged in fishing activities.

21.3.1.2 Vessel to Vessel Collisions

551. Using the pre wind farm vessel routeing (see Section 15.3.5) as input, Anatec's COLLRISK model has been run to estimate the existing vessel to vessel collision risk in proximity to the Hornsea Four HVAC booster station search area.

552. A heat map based upon the geographical distribution of collision risk within a 0.5×0.5 nm grid for the base case is presented in Figure 21.14.

553. Assuming base case vessel traffic levels, the annual collision frequency pre wind farm was estimated to be 5.94×10^{-3}, corresponding to a collision return period of approximately one in 168 years. Compared to assessments undertaken for other sea areas with proposed offshore wind farm developments this is a relatively high background vessel to vessel collision risk level and can be attributed to the presence of a number of heavily trafficked main routes following the UK east coast west and south of the Hornsea Four HVAC booster station search area.

554. As noted previously, the model is calibrated based upon major incident data at sea which allows for benchmarking but does not cover all incidents, such as minor impacts. Other incident data, which includes reported minor incidents, is presented in Section 13.

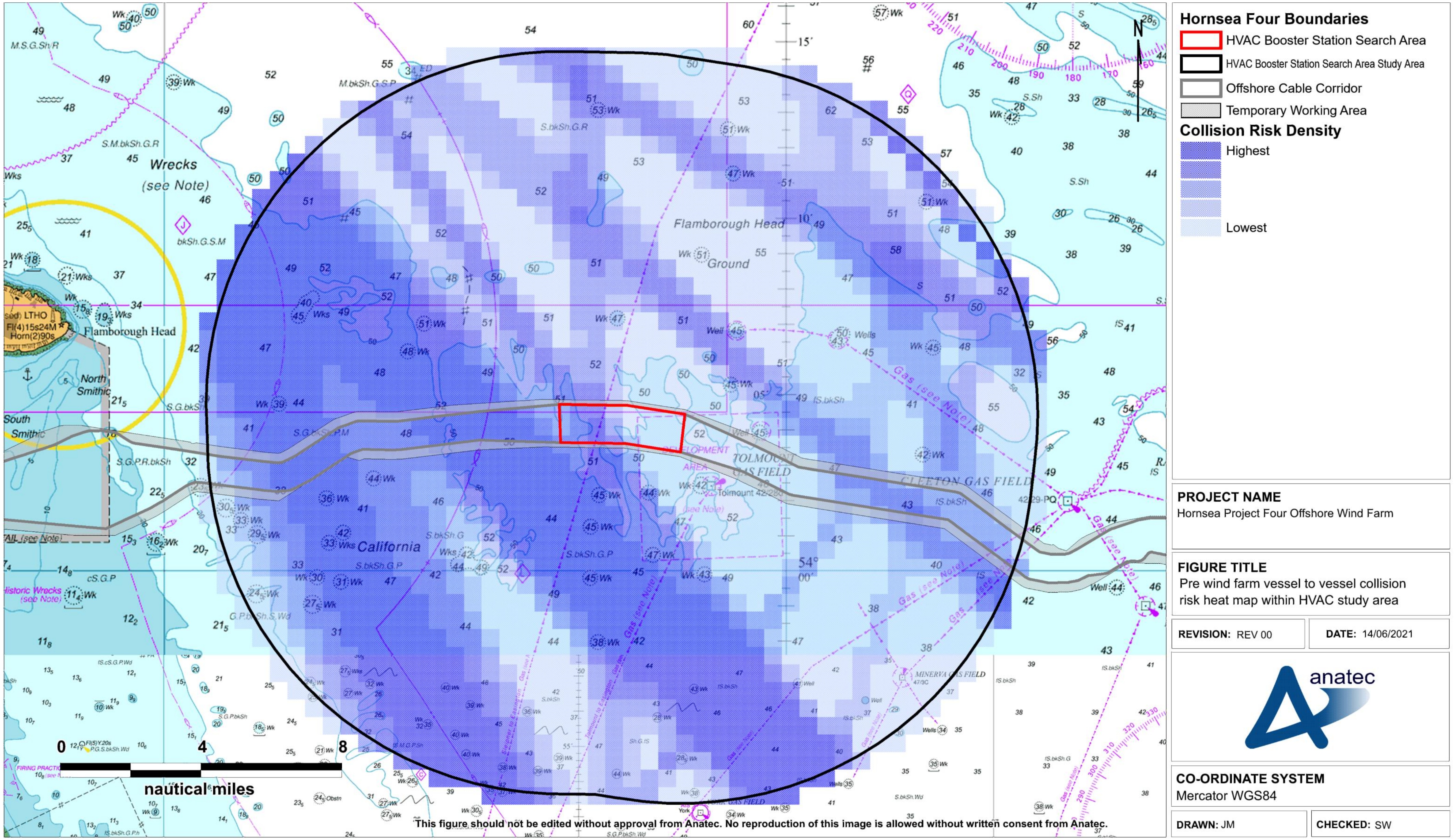

Figure 21.14 Pre wind farm vessel to vessel collision risk heat map for base case within Hornsea Four HVAC booster station search area shipping and navigation study area

21.3.2 Post Wind Farm

21.3.2.1 Simulated Automatic Identification System

555. Anatec's AIS Simulator software was used to gain an insight into the potential re-routed traffic following the installation of structures within the Hornsea Four HVAC booster station search area. The methodology used to simulate AIS tracks is outlined in Section 21.2.2.

556. A plot of 28 days of simulated AIS within the Hornsea Four HVAC booster station search area shipping and navigation study area based upon the deviated main routes is presented in Figure 21.15.

557. It can be seen that the areas of highest routeing density are on the heavily trafficked routes located west and south of the HVAC booster stations. There is also moderate density directly west of the HVAC booster stations where there the two deviated main routes intersect. It is noted that the simulated AIS represents an MDS based upon a mean 1 nm passing distance from the HVAC booster stations for passing routes.

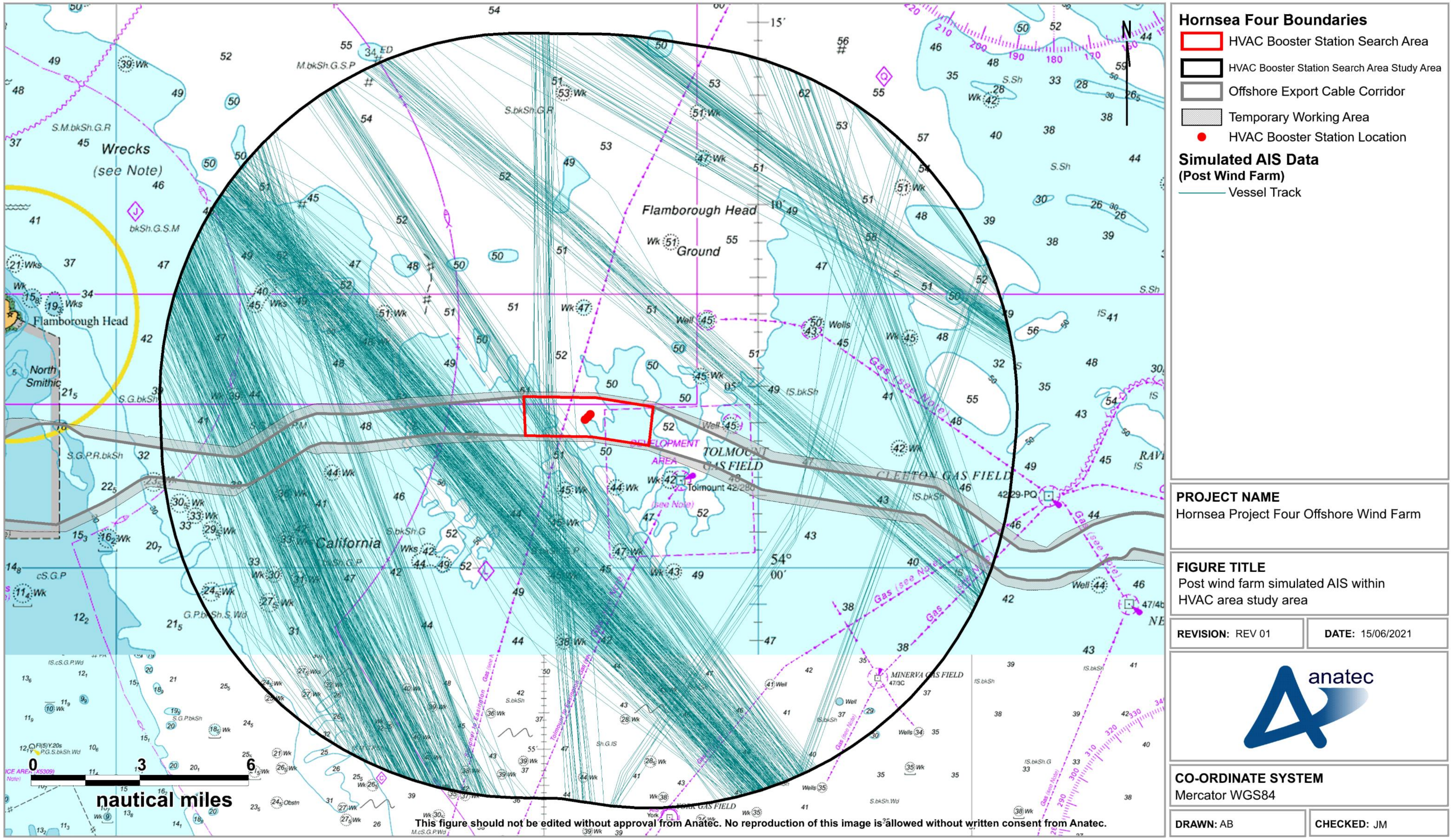

Figure 21.15 Post wind farm simulated AIS tracks for base case within Hornsea Four HVAC booster station search area shipping and navigation study area (28 days)

21.3.2.2 Vessel to Vessel Collisions

558. Using the post wind farm routeing as input, Anatec's COLLRISK model was run to estimate the vessel to vessel collision risk in proximity to the Hornsea Four HVAC booster station search area.

559. A heat map based upon the geographical distribution of collision risk within a 0.5×0.5 nm grid for the base case is presented in Figure 21.16.

560. Assuming base case vessel traffic levels, the annual collision frequency post wind farm was estimated to be 6.00×10^{-3}, corresponding to a collision return period of approximately one in 167 years. This represents a 0.9% increase in collision frequency compared to the base case pre wind farm result. Results for the future cases (pre and post wind farm) are included in Table 21.4.

561. Given that only two routes were required to deviate around the HVAC booster stations and the magnitude of the deviations were small (both less than 0.1 nm), changes in collision risk occurred only in proximity to the HVAC booster stations, and therefore the overall change in collision risk throughout the Hornsea Four HVAC booster station search area shipping and navigation study area was very low.

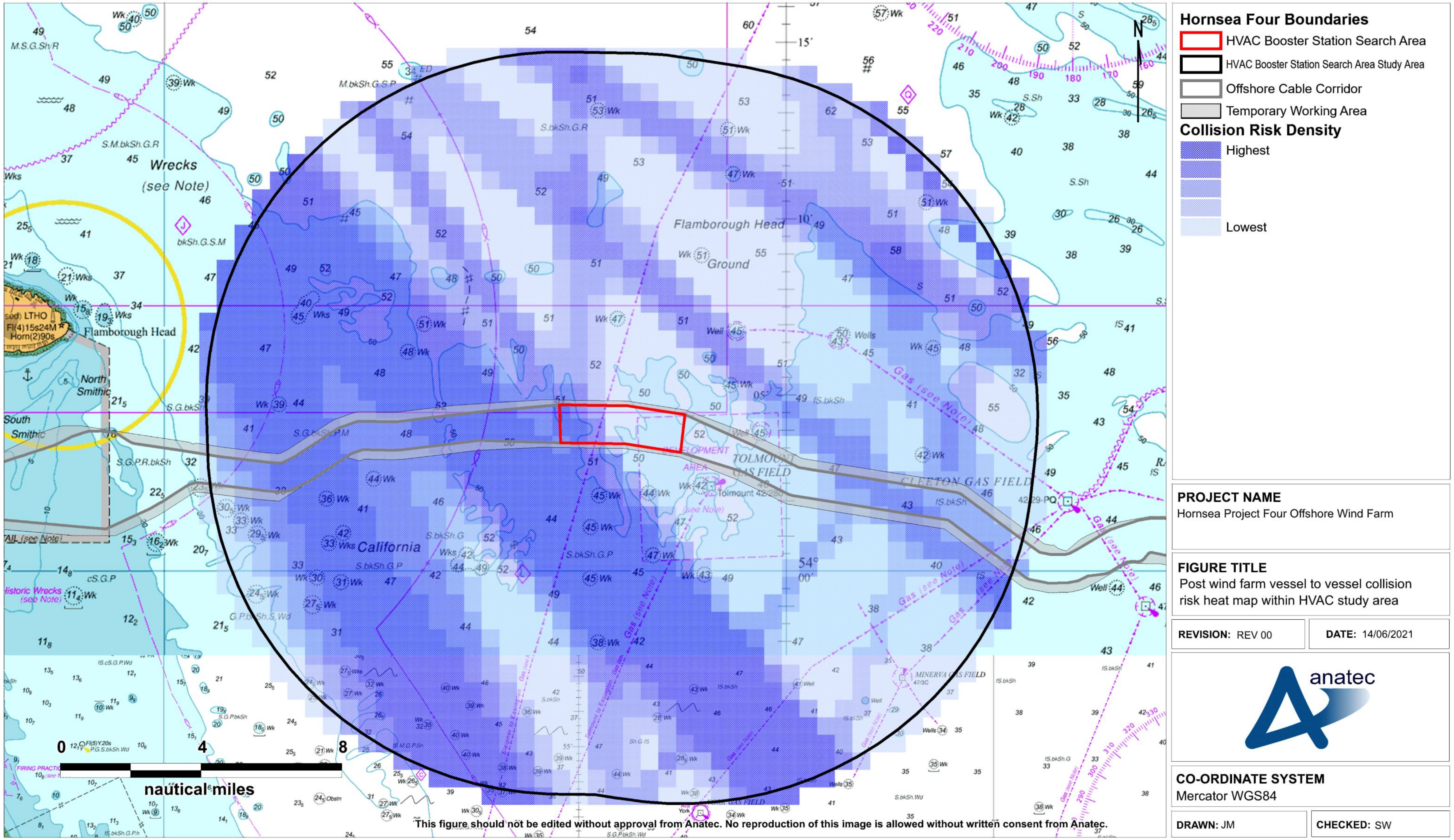

Figure 21.16 Post wind farm vessel to vessel collision risk heat map for base case within Hornsea Four HVAC booster station search area shipping and navigation study area

21.3.2.3 Powered Vessel to Hornsea Four Structure Allision

562. For the same reasons as outlined for the Hornsea Four array area, the frequency of an errant vessel under power deviating from its route to the extent that it comes into proximity with the Hornsea Four HVAC booster station search area is considered to be low.

563. Using the post wind farm routeing as input, alongside the indicative HVAC booster station locations and local Metocean data, Anatec's COLLRISK model was run to estimate the likelihood of a commercial vessel alliding with one of the HVAC booster stations whilst under power. To maintain the need to assess an MDS, the model did not take into account the possibility of one structure shielding another.

564. Table 21.2 provides details of the results for each of the HVAC booster stations and the overall result.

Table 21.2 Powered allision risk per HVAC booster station for base case

Powered Allision Risk			Total
Western	Central	Eastern	
5.52×10^{-4} (1 in 1,810 years)	3.20×10^{-4} (1 in 3,120 years)	1.82×10^{-4} (1 in 5,490 years)	1.05×10^{-3} (1 in 948 years)

565. Assuming base case vessel traffic levels, the annual powered allision frequency post wind farm was estimated to be 1.05×10^{-3}, corresponding to an allision return period of approximately one in 948 years. Results for the future case are included in Table 21.4.

566. The greatest powered vessel to structure allision risk was associated with the western HVAC booster station, for which the allision risk was approximately 5.52×10^{-4} or one in 1,810 years. This reflects the fact that this location was the closest to a number of heavily trafficked main routes, as well as the two main routes deviated due to the presence of the HVAC booster stations.

21.3.2.4 Drifting Vessel to Structure Allision

567. Using the post wind farm routeing as input, alongside the indicative HVAC booster station locations and local Metocean data, Anatec's COLLRISK model was run to estimate the likelihood of a drifting commercial vessel alliding with one of the HVAC booster stations.

568. The methodology used by Anatec's COLLRISK model for drifting allisions is outlined in Section 21.2.2. As per the quantitative assessment for the Hornsea Four array area, three drift scenarios were modelled, with the wind dominated scenario established as producing the worst case results. Table 21.3 provides details of the results for each of the HVAC booster stations and the overall result.

Table 21.3 Drifting allision risk per HVAC booster station for base case

Drifting Allision Risk			Total
Western	Central	Eastern	
2.93×10^{-5} (1 in 34,100 years)	8.62×10^{-6} (1 in 116,000 years)	7.29×10^{-6} (1 in 137,000 years)	4.52×10^{-5} (1 in 22,100 years)

569. Assuming base case vessel traffic levels, the annual drifting allision frequency post wind farm was estimated to be 4.52×10^{-5}, corresponding to an allision return period of approximately one in 22,100 years. Results for the future case are included in Table 21.4.

570. The highest drifting vessel to structure allision risk was associated with the western HVAC booster station, for which the allision risk was approximately 2.93×10^{-5} or one in 34,100 years. This again reflects the fact that this location was the closest to a number of relatively heavily trafficked main routes, as well as the two main routes deviated due to the presence of the HVAC booster stations.

21.3.2.5 Fishing Vessel to Structure Allision

571. Given that the HVAC booster stations are located within a small area (each separated by 100 m) and the fishing vessel track which passed closest to the HVAC booster station locations during the vessel traffic surveys was at a distance of over 300 m, it was not considered reasonable to run Anatec's COLLRISK fishing risk model for the HVAC booster stations.

572. It is however noted from the vessel traffic survey data that the most prominent fishing vessel activity in the area was transits in and out of Bridlington which are less likely to pose an allision risk given the relatively short period of time they are in proximity to the HVAC booster stations.

21.3.3 Risk Results Summary

573. The previous sections modelled two scenarios, namely the pre and post wind farm scenarios each with base case traffic levels. In order to incorporate the potential for future traffic growth pre and post wind farm scenarios each with future case traffic levels have also been modelled. Table 21.1 summarises the results of all four scenarios.

Table 21.4 Summary of annual collision and allision risk results for Hornsea Four HVAC booster stations

Collision/ Allision Scenario	Base Case			Future Case		
	Pre Wind Farm	Post Wind Farm	Change	Pre Wind Farm	Post Wind Farm	Change
Vessel to vessel collision	5.94×10^{-3} (1 in 168 years)	6.00×10^{-3} (1 in 167 years)	5.40×10^{-5} (1 in 18,500 years)	7.21×10^{-3} (1 in 139 years)	7.28×10^{-3} (1 in 137 years)	6.53×10^{-5} (1 in 15,300 years)
Powered vessel to structure allision	N/A	1.05×10^{-3} (1 in 948 years)	1.05×10^{-3} (1 in 948 years)	N/A	1.16×10^{-3} (1 in 862 years)	1.16×10^{-3} (1 in 862 years)
Drifting vessel to structure allision	N/A	4.52×10^{-5} (1 in 22,100 years)	4.52×10^{-5} (1 in 22,100 years)	N/A	4.97×10^{-5} (1 in 20,100 years)	4.97×10^{-5} (1 in 20,100 years)
Total	**5.94×10^{-3} (1 in 168 years)**	**7.10×10^{-3} (1 in 141 years)**	**1.15×10^{-3} (1 in 867 years)**	**7.21×10^{-3} (1 in 139 years)**	**8.49×10^{-3} (1 in 118 years)**	**1.28×10^{-3} (1 in 784 years)**

574. Overall, the collision and allision frequency for the Hornsea Four HVAC booster stations was estimated to increase by approximately 1.15×10^{-3} (one incident in 867 years) for the base case and 1.28×10^{-3} (one incident in 784 years) for the future case.

22 Impact Identification

575. This section outlines the shipping and navigation impacts which have been identified based upon the baseline data and consultation undertaken. These impacts have been fed into the FSA undertaken within **Volume A2, Chapter 7: Shipping and Navigation** where the magnitude of impact and sensitivity of the receptor are assessed to provide a significance of effect.

576. Impacts associated with vessels engaged in fishing are contained in **Volume A2, Chapter 6: Commercial Fisheries**. Impacts associated with oil and gas receptors other than vessel transits are contained in **Volume A2, Chapter 11: Infrastructure and Other Users**. An impact of a commercial nature for shipping has been identified but not included in this section since there is no navigational safety aspect; however, this impact is assessed within **Volume A2, Chapter 7: Shipping and Navigation**.

22.1 Construction Phase

577. *Construction activities associated with the Hornsea Four array area, offshore ECC and HVAC booster station search area may cause vessels to be deviated leading to increased encounters and therefore may also lead to increased vessel to vessel collision risk for all vessels in all weather conditions (SN-C-1).*

578. *Pre-commissioned structures within the Hornsea Four array area and HVAC booster station search area will create powered and drifting allision risk for all vessels (SN-C-2).*

579. *Pre-commissioned cables associated with the Hornsea Four array area and offshore ECC may increase anchor snagging risk for all vessels (SN-C-3).*

580. *Construction activities associated with the Hornsea Four array area and offshore ECC may restrict the emergency response capability of existing resources (SN-C-4).*

22.2 Operation and Maintenance Phase

581. *Presence of structures within the Hornsea Four array area, offshore ECC and HVAC booster station search area and activities associated with the Hornsea Four array area, offshore ECC and HVAC booster station search area may cause vessels to be deviated leading to increased encounters and therefore increased vessel to vessel collision risk for all vessels in all weather conditions (SN-O-5).*

582. *Operational structures within the Hornsea Four array area and HVAC booster station search area may create powered and drifting allision risk for all vessels (SN-O-6).*

583. *Operational cables within the Hornsea Four array area and offshore ECC may increase anchor snagging risk for all vessels and cable protection may reduce navigable water depths for all vessels (SN-O-7).*

584. *Operation and maintenance activities associated with the Hornsea Four array area and offshore ECC may restrict the emergency response capability of existing resources (SN-O-8).*

585. *Operational structures within the Hornsea Four array area and offshore ECC may impact a vessel's use of its Radar, communications and navigation equipment during navigational transits (SN-O-9).*

22.3 Decommissioning Phase

586. *Decommissioning activities associated with the Hornsea Four array area and HVAC booster station search area may cause vessels to be deviated leading to increased encounters and therefore may also lead to increased vessel to vessel collision risk for all vessels in all weather conditions (SN-D-10).*

587. *Decommissioning structures within the Hornsea Four array area and HVAC booster station search area will create powered and drifting allision risk for all vessels (SN-D-11).*

588. *Decommissioning cables left in situ within the Hornsea Four array area and offshore ECC may increase anchor snagging risk for all vessels (SN-D-12).*

589. *Decommissioning activities associated with the Hornsea Four array area and offshore ECC may restrict the emergency response capability of existing resources (SN-D-13).*

23 Commitments Included as Part of Hornsea Four

590. As part of the Hornsea Four design process, a number of commitments included by Hornsea Four have been proposed to reduce the potential for impacts on shipping and navigation. These commitments are considered standard industry practice for this type of development and are summarised in Section 7.8 of **Volume A2, Chapter 7: Shipping and Navigation**, with all Hornsea Four commitments detailed in **Volume A4, Annex 5.2: Commitments Register**.

591. The following subsections provide additional details on some commitments, including in relation to marine aids to navigation and other lighting and marking considerations. These are covered by Co93 in **Volume A4, Annex 5.2: Commitments Register**.

23.1 Marine Aids to Navigation

592. Throughout the construction and operation and maintenance of Hornsea Four, aids to navigation will be provided in accordance with Trinity House and MCA requirements, with consideration being given to *IALA Recommendation O-139 on the Marking of Man-Made Offshore Structures* (IALA, 2013), the *Standard Marking Schedule for Offshore Installations* (DECC, 2011) and MGN 654 (MCA, 2021).

23.1.1 Construction and Decommissioning Markings

593. During the construction and decommissioning of Hornsea Four, buoyed construction and decommissioning areas will be established and marked, where required, in accordance with Trinity House requirements based upon the IALA Maritime Buoyage System. In addition to this, where advised by Trinity House additional buoyage marking on structures may also be applied.

594. Notifications to Mariners (including local), radio navigational warnings, NAVTEX and/or broadcast warnings as well as Notices to Airmen will be promulgated in advance of any proposed works, where required.

23.1.2 International Association of Marine Aids to Navigation and Lighthouse Authorities Guidance on the Marking of Groups of Structures

595. It is noted that the IALA O-139 guidance does not have to be followed and that Trinity House may request additional or alternative mitigations; however it is assumed that the peripheral lighting will consist of significant peripheral structures (SPS), noting that Trinity House are currently phasing out the use of intermediate peripheral structures (IPS) which have typically been used in the past. Given the distance offshore and the minimum spacing, further variations to the standard guidance may be required in consultation with the statutory stakeholders.

596. No lighting or physical marking will be required during the operation and maintenance phase for the export cables.

597. The HVAC booster stations will be marked as isolated structures, regardless of how far apart they are located.

598. Relevant guidance from the MCA and CAA will also be considered during the operation and maintenance phase. This is likely to include:

- Red aviation lighting synchronised Morse “W”;
- SAR helicopter lights;
- Heli-hoist lights for day-to-day operation; and
- Audible warnings.

23.2 Other Lighting and Marking Considerations

599. The following subsections identify additional measures which are requirements or are currently under consideration by Hornsea Four but will require consultation post consent.

23.2.1 Low Level Lighting on Foundations

600. Use of low-level lighting and retro reflective areas on signage, access platforms and ladders will be required.

23.2.2 Day Marks

601. The tower of every WTG (or relevant components) should be painted yellow all-round from the level of Highest Astronomical Tide (HAT) to 15 m or the height of the aid to navigation, if fitted, whichever is greater. Alternative marking may include horizontal yellow bands of not less than 2 m height and separation.

23.2.3 Location of Lights

602. The aids to navigation on the structure of a WTG will be mounted below the lowest point of the arc of the rotor blades. They should be exhibited at a height of at least 6 m above HAT.

23.2.4 Use of AIS Transmitters, Virtual Buoys and Radar Beacons

603. AIS transmitters, virtual buoys and/or Radar Beacons (Racon) may be used following consultation with Trinity House. If required, these would be placed on the periphery of the array to assist safe navigation particularly in reduced visibility. AIS transmitters or virtual buoys could also be considered internally to assist with navigation within the Hornsea Four array area.

23.2.5 Sound Signals

604. Sound signals will be provided where appropriate, taking into account the prevailing visibility and vessel traffic conditions. The typical range of such a sound signal should not be less than 2 nm.

23.2.6 Spurious White Lights

605. Additional white lights will be kept to a minimum and Hornsea Four will ensure that regular checks are undertaken to identify any lights which should not be visible are extinguished after use.

23.2.7 Aviation Lighting

606. Aviation lighting will be as per CAA requirements; however, they will be synchronised to Morse "W" at the request of Trinity House.

23.2.8 Remote Monitoring Sensors

607. Remote monitoring sensors using Supervisory Control and Data Acquisition (SCADA) will be included as part of the lighting and marking scope to ensure a high level availability for all aids to navigation.

23.2.9 Numbering of Structures

608. The MCA will advise post consent on the specific requirements for the numbering of Hornsea Four structures; however, a logical pattern with potential for additional visual marks may be considered by statutory stakeholders.

23.2.10 Gap Between Hornsea Four and Hornsea Project Two

609. During consultation, additional aids to navigation were discussed for the gap between Hornsea Four and Hornsea Project Two and it was deemed likely that no specialised aids to navigation would be required; however this will be agreed post-consent as part of the lighting and marking sign-off process (Co93).

23.3 Design Specifications Noted in Marine Guidance Note 654

610. The individual WTGs and other structures will have functions and procedures in place for generator shut down in emergency situations, as per Annex 5 of MGN 654 (MCA, 2021).

24 Cost Benefit Analysis

611. The FSA Guidelines require a process of CBA to rank the proposed commitment (risk control) options in terms of risk benefit related to lifecycle costs. This will be considered in terms of Gross Cost of Averting a Fatality (GCAF). This is a cost effectiveness measure in terms of ratio of marginal (additional) cost of the risk control option to the reduction in risk to personnel in terms of the fatalities averted.

612. Until the array layout and associated commitments are finalised, a review of CBA cannot be undertaken; however, Hornsea Four intend to implement commitments which show a positive effect on the impact and a reduction in worst case PLL value in conjunction with the frequency of occurrence.

613. Further work will be undertaken post consent once final commitments are known in line with standard industry practice.

25 Through Life Safety Management

25.1 Quality, Health, Safety and Environment

614. Quality, Health, Safety and Environment (QHSE) documentation including a Safety Management System will be in place for Hornsea Four and will be continually updated throughout the development process. The following subsections provide an overview of documentation and how it will be maintained and reviewed with reference, where required, to specific marine documentation.

615. Monitoring, reviewing and auditing will be carried out on all procedures and activities and feedback actively sought. The designated person (identified in QHSE documentation), managers and supervisors are to maintain continuous monitoring of all marine operations and determine if all required procedures and processes are being correctly implemented.

25.2 Incident Reporting

616. After any incidents, including near misses, an incident report form will be completed in line with the Hornsea Four QHSE documentation. This will then be assessed for relevant outcomes and reviewed for possible changes required to operations.

617. Hornsea Four shall maintain records of investigation and analyse incidents in order to:

- Determine underlying deficiencies and other factors that may be causing or contributing to the occurrence of incidents;
- Identify the need for corrective action;
- Identify opportunities for preventive action;
- Identify opportunities for continual improvement; and
- Communicate the results of such investigations.

618. All investigations shall be performed in a timely manner.

619. A database (lessons learnt) of all marine incidents will be developed. It will include the outcomes of investigations and any resulting actions. Hornsea Four will promote awareness of their potential occurrence and provide information to assist monitoring, inspection and auditing of documentation.

620. When appropriate, the designated person (noted within the Emergency Response Cooperation Plan (ERCoP)) should inform the MCA of any exercise or incidents including any implications on emergency response. If required, the MCA should be invited to take part in incident debriefs.

25.3 Review of Documentation

621. Hornsea Four will be responsible for reviewing and updating all documentation including the risk assessments, ERCoP, safety management system and, if required, Hornsea Four will convene a review panel of stakeholders to quantify risk.

622. Reviews of the risk register should be made after any of the following occurrences:

- Changes to the development, conditions of operation and prior to decommissioning;
- Planned reviews; and
- Following an incident or exercise.

623. A review of potential risks should be carried out annually. A review of the response charts should be carried out annually to ensure that response procedures are up to date and should include any amendments from audits/incident reports/deficiencies.

25.4 Inspection of Resources

624. All vessels, facilities, and equipment necessary for marine operations are to be subject to appropriate inspection and testing to determine fitness for purpose and availability in relation to their performance standards. This will include monitoring and inspection of all aids to navigation to determine compliance with the performance standards specified by Trinity House.

25.5 Audit Performance

625. Auditing and performance review are the final steps in QHSE management systems. The feedback loop enables an organisation to reinforce, maintain and develop its ability to reduce risks to the fullest extent and to ensure the continued effectiveness of the system. Hornsea Four will carry out audits and periodically evaluate the efficiency of the marine safety documentation.

626. The audits and possible corrective actions should be carried out in accordance with standard procedures and results of the audits and reviews should be brought to the attention of all personnel having responsibility in the area involved.

25.6 Safety Management System

627. Hornsea Four will manage the risks associated with the activities undertaken at the Hornsea Four array area, offshore ECC and HVAC booster stations. It shall establish an integrated safety management system which ensures that the safety and environmental impacts of those activities are ALARP. This includes the use of remote monitoring and switching for aids to navigation to ensure that if a light is faulty a quick fix can be instigated from the Marine Helicopter Coordination Centre (MHCC) (to be included in the Lighting and Marking Plan (LMP) and Aids to

Navigation Management Plan which are required under the deemed Marine Licences for Hornsea Four).

25.7 Future Monitoring of Vessel Traffic

628. Whilst no Radar monitoring of vessel movements has been proposed for the Hornsea Four array area, AIS monitoring will be available from a vessel (during construction) and site location (during operation and maintenance) to record the movements of vessels around the Hornsea Four array area.

25.8 Decommissioning Plan

629. A decommissioning plan will be developed. With regards to impacts on shipping and navigation this will include consideration of the scenario where upon decommissioning and completion of removal operations, an obstruction is left on site (attributable to Hornsea Four) which is considered to be a danger to safe navigation and which it has not proven possible to remove. Such an obstruction may require to be marked until such time as it is either removed or no longer considered a danger to navigation.

26 Summary

630. Using baseline data and consultation undertaken, impacts relating to shipping and navigation have been identified for Hornsea Four for all phases of the development (construction, operation and maintenance and decommissioning). This has been fed into the FSA undertaken in **Volume A2, Chapter 7: Shipping and Navigation**. Additionally, a cumulative baseline has also been determined and informs the CEA also undertaken in **Volume A2, Chapter 7: Shipping and Navigation**.

26.1 Consultation

631. Throughout the NRA process, consultation has been undertaken with regulators and stakeholders, including:

- MCA;
- Trinity House;
- UK Chamber of Shipping;
- RYA;
- CA;
- VISNED;
- DFDS Seaways;
- Boston Putford Offshore Safety;
- ABP;
- UKMPG;
- Danish Shipping; and
- National Grid and Energinet (Viking Link Interconnector).

632. Some of these stakeholders attended one or both of the Hazard Workshops in June 2019 and May 2020 during which key maritime hazards associated with the construction and operation and maintenance of Hornsea Four were identified and discussed.

26.2 Existing Environment

633. The Hornsea Four array area is located approximately 1.9 nm north west of the under construction Hornsea Project Two (measured from the consented boundary of Hornsea Project Two to the Hornsea Four Order Limits). Hornsea Project One (operational) and Hornsea Three (consented) are also in proximity and there are a number of other offshore wind farm developments within the southern North Sea including other Round 3 sites in the former Dogger Bank Zone and former East Anglia Zone.

634. Two production wells within the Johnston gas field connected to the Ravenspurn North CCW platform are located within the Hornsea Four array area alongside a suspended well. There are a number of other surface platforms in proximity to the Hornsea Four array area including at the Ravenspurn, Babbage, Garrow and Kilmar

gas fields. Two submarine pipelines associated with gas fields in the southern North Sea pass through the Hornsea Four array area.

635. The Tolmount surface platform is located approximately 1.3 nm south east of the Hornsea Four HVAC booster station search area and forms part of an ODA for the Tolmount gas field which intersects the Hornsea Four HVAC booster station search area.

26.3 Maritime Incidents

636. From MAIB incident data analysed over a 10-year period, an average of one to two unique incidents per year occurred within the Hornsea Four array area shipping and navigation study area with one incident occurring within the Hornsea Four array area itself. This involved a general cargo vessel experiencing an engine failure.

637. An average of two to three unique incidents reported to the MAIB per year occurred within the Hornsea Four offshore ECC shipping and navigation study area with the majority of incidents occurring within 5 nm of the east Yorkshire coast.

638. An average of one unique incident reported to the MAIB per year occurred within the Hornsea Four HVAC booster station search area shipping and navigation study area with the closest incident involving a 12 m fishing vessel which experienced a loss of control approximately 7.1 nm north east.

639. From RNLI incident data analysed over a 10-year period, no RNLI lifeboat launches were reported within the Hornsea Four array area shipping and navigation study area.

640. An average of 15 unique incidents reported to the RNLI per year occurred within the Hornsea Four offshore ECC shipping and navigation study area with the majority of incidents occurring within 5 nm of the east Yorkshire coast.

641. An average of two unique incidents reported to the RNLI per year occurred within the Hornsea Four HVAC booster station search area shipping and navigation study area with fishing vessels the most frequent casualty vessel type.

26.4 Vessel Traffic

26.4.1 Hornsea Four Array Area

642. From vessel traffic survey data recorded on AIS over 14 days in July/August 2020 (summer), there was an average of 34 unique vessels per day recorded within the Hornsea Four array area shipping and navigation study area and seven unique vessels per day within the Hornsea Four array area itself. Cargo vessels, tankers and oil and gas vessels were the main vessel types recorded within the Hornsea Four array area throughout the summer survey period. Recreational vessel activity was minimal while fishing activity was moderate and characteristic of both transits and engagement in fishing activities.

643. From vessel traffic survey data recorded via AIS, visual observations and Radar over 14 full days in February/March 2021 (winter), there was an average of 25 unique vessels per day recorded within the Hornsea Four array area shipping and navigation study area and seven unique vessels per day within the Hornsea Four array area itself. Again, cargo vessels, tankers and oil and gas vessels were the main vessel types recorded within the Hornsea Four array area throughout the winter survey period. Recreational vessel and fishing vessel activity was minimal.

644. A total of 14 main routes were identified within the Hornsea Four array area shipping and navigation study area, with the highest traffic volume routes two transits per day between Immingham and Gothenburg and Newcastle and Amsterdam. These were two of three main routes featuring commercial ferries operated by DFDS Seaways with the other operating between Immingham and Esbjerg.

26.4.2 Hornsea Four Offshore Export Cable Corridor

645. From vessel traffic survey data recorded on AIS over 14 days in July/August 2019 (summer), there was an average of 55 unique vessels per day recorded within the Hornsea Four offshore ECC shipping and navigation study area and 45 unique vessels per day within the Hornsea Four ECC itself. Cargo vessels, tankers and fishing vessels were the main vessel types recorded within the Hornsea Four offshore ECC throughout the summer survey period. Recreational vessel activity was minimal and fishing vessel activity was low out with the nearshore area.

646. From vessel traffic survey data recorded on AIS over 14 days in February 2019 (winter), there was an average of 55 unique vessels per day recorded within the Hornsea Four offshore ECC shipping and navigation study area and 46 unique vessels per day within the Hornsea Four offshore ECC itself. Again, cargo vessels, tankers and fishing vessels were the main vessel types recorded within the Hornsea Four offshore ECC throughout the winter survey period. Recreational vessel and fishing vessel activity was low out with the nearshore area.

26.4.3 Hornsea Four HVAC Booster Station Search Area

647. From vessel traffic survey data recorded on AIS over 14 days in August 2019 (summer), there was an average of 34 unique vessels per day recorded within the Hornsea Four HVAC booster station search area shipping and navigation study area and five unique vessels per day within the Hornsea Four HVAC booster station search area itself. Cargo vessels and tankers were the main vessel types recorded within the Hornsea Four HVAC booster station search area throughout the summer survey period. Recreational vessel activity was low while fishing activity was notable and characteristic of both transits (primarily out of Bridlington) and engagement in fishing activities.

648. From vessel traffic survey data recorded via AIS, visual observations and Radar over 14 full days in March 2021 (winter), there was an average of 47 unique vessels per

day recorded within the Hornsea Four HVAC booster station search area shipping and navigation study area and four unique vessels per day within the Hornsea Four HVAC booster station search area itself. Oil and gas vessels, tankers and cargo vessels were the main vessel types recorded within the Hornsea Four HVAC booster station search area throughout the winter survey period. Recreational vessel activity was minimal while fishing activity was notable and characteristic of both transits (primarily out of Bridlington) and engagement in fishing activities.

649. A total of 12 main routes were identified within the Hornsea Four HVAC booster station search area shipping and navigation study area, with the highest traffic volume route on average nine transits per day between the Tees and Rotterdam/ Zeebrugge. This main route featured commercial ferries operated primarily by P&O Ferries.

26.5 Future Case Vessel Traffic

650. An indicative 10% increase in traffic associated with ports, commercial fishing vessel transits and recreational vessel transits was considered for the future case scenario. Additionally, transits made by vessels involved in the installation and operation and maintenance of Hornsea Four were considered.

651. Deviations would be required for five out of the 14 main routes identified within the Hornsea Four array area shipping and navigation study area following construction of Hornsea Four, with the level of deviation varying between 0.4 and 5.5 nm. For the largest deviation, this corresponds to a 1.5% increase in the total route length.

652. A deviation would be required for two out of the 12 main routes identified within the Hornsea Four HVAC booster station search area shipping and navigation study area following construction of Hornsea Four, with these being deviations of less than 0.1 nm in both cases, corresponding to a very small change in the total route length.

26.6 Collision and Allision Risk Modelling

26.6.1 Hornsea Four Array Area

653. An assessment of current vessel to vessel encounters in proximity to the Hornsea Four array area was undertaken by replaying at high speed the data collected as part of the vessel traffic surveys. There was an average of nine encounters per day within the Hornsea Four array area shipping and navigation study area. The day with the greatest number of encounters was 1st August 2020 when 20 encounters were recorded.

654. The annual vessel to vessel collision risk for the base case in proximity to the Hornsea Four array area was estimated to be 6.64×10^{-3}, corresponding to a collision

return period of approximately one in 151 years. This represents a 14% increase in collision frequency compared to the pre wind farm result.

655. The annual powered vessel to structure allision risk following installation of the Hornsea Four array area for the base case was estimated to be 1.08×10^{-3}, corresponding to an allision return period of approximately one in 929 years.

656. After modelling three drift scenarios it was established that the ebb tide dominated scenario produced the worst case results. The annual drifting vessel to structure allision risk following installation of the Hornsea Four array area for the base case was estimated to be 1.16×10^{-3}, corresponding to an allision return period of approximately one in 866 years.

657. The annual fishing vessel to structure allision risk following installation of the Hornsea Four array area for the base case was estimated to be 4.51×10^{-2}, corresponding to an allision return period of approximately one in 22 years.

26.6.2 Hornsea Four HVAC Booster Stations

658. An assessment of current vessel to vessel encounters in proximity to the Hornsea Four HVAC booster station search area was undertaken by replaying at high speed the data collected as part of the vessel traffic surveys. There was an average of 25 encounters per day within the Hornsea Four HVAC booster station search area shipping and navigation study area. The day with the greatest number of encounters was 21st March 2021 when 56 encounters were recorded.

659. The annual vessel to vessel collision risk in proximity to the Hornsea Four HVAC booster station search area for the base case was estimated to be 6.00×10^{-3}, corresponding to a collision return period of approximately one in 167 years. This represents a 0.9% increase in collision frequency compared to the pre wind farm result.

660. The annual powered vessel to structure allision risk following installation of the Hornsea Four HVAC booster stations for the base case was estimated to be 1.05×10^{-3}, corresponding to an allision return period of approximately one in 948 years.

661. After modelling three drift scenarios it was established that the wind dominated scenario produced the worst case results. The annual drifting vessel to structure allision risk following installation of the HVAC booster stations for the base case was estimated to be 4.52×10^{-5}, corresponding to an allision return period of approximately one in 22,100 years.

26.7 Summary of Impacts for the Environmental Statement

662. Following the first Hazard Workshop, the risks associated with the identified hazards were ranked and appropriate commitments identified, with a hazard log

subsequently compiled which was consulted upon with stakeholders. This hazard log was then updated to reflect the outputs of the second Hazard Workshop and reviewed following a further change to the Hornsea Four array area boundary.

663. Using the hazard log in addition to the baseline data and additional consultation undertaken (including Section 42 Consultation) impacts relating to the safety of navigation have been identified and fed into the FSA undertaken within **Volume A2, Chapter 7: Shipping and Navigation** where the magnitude of impact and sensitivity of the receptor are assessed to provide a significance of effect. The impacts considered are summarised below:

- Deviation of vessels around the Hornsea Four array area, offshore ECC and HVAC booster station search area leading to increased encounters and consequent increased vessel to vessel collision risk for all vessels in all weather conditions (all phases);
- Powered and drifting allision risk for all vessels with structures within the Hornsea Four array area and HVAC booster station search area (all phases);
- Anchor snagging risk for all vessels with cables associated with the Hornsea Four array area and offshore ECC (all phases);
- Restricted emergency response capability of existing resources due to activities associated with the Hornsea Four array area and offshore ECC (all phases);
- Reduced navigable depths for all vessels due to cable protection (operation and maintenance phase); and
- Impacted use of a vessel's Radar, communications and navigation equipment during navigational transits due to structures within the Hornsea Four array area and offshore ECC (operation and maintenance phase).

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