

Offshore
Wind
Leasing
Round 4

Resource and Constraints
Assessment for Offshore Wind

Characterisation Area Report
East Anglia

6

Characterisation Area Report: 6 - East Anglia

38255-TCE-REP-011 Characterisation Area Report: 6 – East Anglia		
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1.1	Draft	July 2018
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1.3	Final	September 2019

The information included in this report should be read in conjunction with the *Resource and Constraints Assessment for Offshore Wind: Methodology Report* and the *Summary Stakeholder Feedback Report*. The trigger distance for constraints to be included in the constraints analysis section of this report is 1 nautical mile (NM).

The Crown Estate has undertaken the analysis in this report using the evidence available to it, internal expertise and support from external advisers where appropriate. The analysis does not obviate any potential need for any Habitat Regulations Assessment (HRA) or any project level consideration of the potential impact of development. The analysis does not supersede any statutory policies or marine plans. The analysis, including the data and information contained in this document, presents a point in time assessment with changes likely to both the presence and nature of constraints.

This report is provided for information purposes only and no party may rely on the accuracy, completeness or fitness of its content for any particular purpose. The Crown Estate makes no representation, assurance, undertaking or warranty in respect of the analysis in the report including all data and information contained in it.

Receptor rating		Area rating	
Receptor assessed but no interaction noted		Receptor assessed but no interaction noted	
Interaction acceptable with best practice/accepted mitigation		The constraint will present the need to implement best practice/accepted mitigation measures to enable acceptable development within the whole area	
Interaction acceptable with moderate mitigation		The constraint will present the need to implement moderate mitigation measures to enable acceptable development within the whole area	
Interaction acceptable with significant mitigation		The constraint will present the need to implement significant and/or strategic level mitigation measures to enable acceptable development within the whole area	
Significant/insurmountable issue that would be challenging to mitigate within the area of influence of a receptor		Significant/insurmountable issue that would be challenging to mitigate for any development within the whole area	
No data coverage across the area		No data coverage across the area	

Constraints analysis

Note that in addition to The Crown Estate leases/licences within this table, The Crown Estate has also identified key resource areas (KRAs) which may be suitable for the future development of different marine sectors. Information about overlapping KRAs that overlap this characterisation area is described in a latter section of this document.

Exclusions model — Hard constraints			Receptor rating	Area rating
	Present	Commentary		
The Crown Estate agreements	Telecoms cables: there are numerous active and inactive cables intersecting the characterisation area as they head into Sizewell.	The cables have been removed from the characterisation area and should be avoided where possible by using best practice/accepted mitigation. However, the large number of cables, particularly in the north of the characterisation area may be a constraint on the available area for new arrays. Since cable crossings require cable protection (which may have adverse environmental effects), crossings should be minimised where practicable.	Green	Yellow
	East Anglia One Wind Farm: within the southern part of the characterisation area.	The cumulative impact of offshore wind farm (OWF) developments and associated cable infrastructure will need to be considered in this area as there may be concerns around wind resource and proximity to the existing site. There will need to be a 5 km buffer around existing offshore wind projects – any new wind developments within 5 km will need the permission of the incumbent party.	Orange	Yellow
	East Anglia One North Wind Farm: within the central part of the characterisation area.	The cumulative impact of OWF developments and associated cable infrastructure will need to be considered in this area as there may be concerns around wind resource and proximity to the existing site. There will need to be a 5 km buffer around existing offshore wind projects – any new wind developments within 5 km will need the permission of the incumbent party.	Orange	Yellow
	East Anglia North Tranche One East (Norfolk Vanguard East): within the northern part of the characterisation area.	The cumulative impact of OWF developments and associated cable infrastructure will need to be considered in this area as there may be concerns around wind resource and proximity to the existing site. There will need to be a 5 km buffer around existing offshore wind projects – any new wind developments within 5 km will need the permission of the incumbent party.	Orange	Yellow
	East Anglia North Tranche One West (Norfolk Vanguard West): adjacent to the northern boundary of the characterisation area.	The cumulative impact of OWF developments and associated cable infrastructure will need to be considered in this area as there may be concerns around wind resource and proximity to the existing site. There will need to be a 5 km buffer around existing offshore wind projects – any new wind developments within 5 km will need the permission of the incumbent party.	Orange	Yellow
	East Anglia North Tranche Two (Norfolk Boreas): adjacent to the northern boundary of the characterisation area.	The cumulative impact of OWF developments and associated cable infrastructure will need to be considered in this area as there may be concerns around wind resource and proximity to the existing site. There will need to be a 5 km buffer around existing offshore wind projects – any new wind developments within 5 km will need the permission of the incumbent party.	Orange	Yellow
	East Anglia Two Wind Farm: within the southern part of the characterisation area.	The cumulative impact of OWF developments and associated cable infrastructure will need to be considered in this area as there may be concerns around wind resource and proximity to the existing site. There will need to be a 5 km buffer around existing offshore wind projects – any new wind developments within 5 km will need the permission of the incumbent party.	Orange	Yellow
	East Anglia Three Wind Farm: within the northern part of the characterisation area.	The cumulative impact of OWF developments and associated cable infrastructure will need to be considered in this area as there may be concerns around wind resource and proximity to the existing site. There will need to be a 5 km buffer around existing offshore wind projects – any new wind developments within 5 km will need the permission of the incumbent party.	Orange	Yellow
	OWF export cable routes (OFTOs): numerous within and adjacent to the characterisation area.	The characterisation area cable routes should be avoided where possible and liaison would be required with existing customers. However, any concerns can likely be avoided with best practice/accepted mitigation. Conflicts may arise where there are numerous export cable routes around the same landfall area, as connections to the grid may be limited and environmental sensitivities cause a consent risk. Since cable crossings require cable protection (which may have adverse environmental effects), crossings should be minimised where practicable.	Yellow	Green
	Aggregates area 494: active dredge site within the north-western part of the characterisation area.	Would require 2 km buffer around it and negotiations with the customer.	Orange	Green
	Aggregates area 430: active dredge site within the central south-western part of the characterisation site.	Would require 2 km buffer around it and negotiations with the customer.	Orange	Green
	Aggregates area 511: active dredge site within the western part of the characterisation site.	Would require 2 km buffer around it and negotiations with the customer.	Orange	Green
	Aggregates area 228: active dredge site within the western part of the characterisation site.	Would require 2 km buffer around it and negotiations with the customer.	Orange	Green
	Aggregates area 240: active dredge site within the western part of the characterisation site.	Would require 2 km buffer around it and negotiations with the customer.	Orange	Green

	Aggregates area 401/2a: active dredge site within the western part of the characterisation site.	Would require 2 km buffer around it and negotiations with the customer.		
	Aggregates area 512: active dredge site within the western part of the characterisation site.	Would require 2 km buffer around it and negotiations with the customer.		
	Aggregates area 212: active dredge site within the north-western part of the characterisation area.	Would require 2 km buffer around it and negotiations with the customer.		
	Aggregates area 525: active dredge site within the western part of the characterisation area.	Would require 2 km buffer around it and negotiations with the customer.		
	Aggregates area 242/361: active dredge site within the western part of the characterisation area.	Would require 2 km buffer around it and negotiations with the customer.		
	Aggregates area 513/1 and 2: active dredge site within the western part of the characterisation area.	Would require 2 km buffer around it and negotiations with the customer.		
	Aggregates area 254: active dredge site within the western part of the characterisation site.	Would require 2 km buffer around it and negotiations with the customer.		
Other energy infrastructure	No existing oil and gas infrastructure triggered in the area.	There are no oil and gas platforms in the area itself and less than 1% of the characterisation area is covered by the 3-6 NM helicopter consultation buffers from oil and gas platforms to the north, with 4% being affected by the lower risk 6-9 NM consultation buffer.		
Navigation	There is a traffic separation scheme transecting the area defining the deep-water route access into the Southern North Sea.	The schemes mean that traffic is concentrated into defined routes due to volume and navigation and safety reasons. Any impact on the traffic separation scheme should be avoided where possible. Other space is limited in the area with existing wind farm developments already abutting shipping routes.		
Social	None within the trigger distance.			
Restrictions model — Soft constraints			Receptor rating	Area rating
Economic tier				
Navigation	There is one deep-water anchorage that adjacent to the area situated approximately 600 m to the south-west of the area.	There are significant other opportunities in the area to allow mitigation/avoidance of this interaction.		
	There is one disposal site intersecting the area.	These are not of a size or location that will cause a significant constraint to development.		
	There are four major shipping routes transecting the area: two tracking north-west to south-east, one tracking directly north and one north-east.	There is a significant amount of shipping activity in the area, although the data shows this follows relatively well-defined tracks, there are gaps of development potential. However, careful consideration of safety and cumulative impacts is required as well as consideration of safe depths for navigation.		
Subsurface	None within the trigger distance.			
Fishing	See fisheries commentary below.		N/A	

Environmental tier							
The assessment of the sensitivity of Marine Protected Areas (MPAs) to pressures caused by offshore wind development and operation is assessed in a separate spreadsheet which will be made available as part of the Round 4 evidence base. Commentary has been noted in the relevant characterisation document where MPAs either overlap or are within 1 NM of the characterisation area and have been assessed as a yellow rating or above. For more information on the methodology for this assessment, please refer to the methodology report.							
Assessments of Annex II species have not been made as part of the characterisation process. Such assessments will need to be undertaken at project level for individual developments within the characterisation area.							
Type of designation	Name of designation	Designation features/species	Conservation objectives	Commentary	Receptor rating	Area rating	
European marine designations	Special Area of Conservation (SACs)	Haisborough; Hammond and Winterton	Subtidal sandbanks Reefs	Currently in unfavourable condition. Conservation objectives are to restore features to favourable condition.	<p>The sandbank and reef features are both considered sensitive to pressures exerted by offshore wind development and operation (including cabling) and an assessment of impact will need to be made at project level. The area will be sensitive to significant changes in sediment dynamics as well as direct impacts on the features. Impacts are may be mitigable with appropriate locating of project/cable, especially since the majority of the site has been excluded from the characterisation area.</p> <p>The Wildlife Trusts note that the current unfavourable condition of the site should mean that further development within it is excluded.</p> <p>Consideration should be given to the SNCB's report on cable sensitivity entitled 'Natural England and JNCC advice on key sensitivities of habitats and Marine Protected Areas in English Waters to offshore wind farm cabling within Proposed Round 4 leasing areas'.</p>	Red	Yellow
	Harbour porpoise SAC	Southern North Sea	Harbour porpoise	<p>To ensure that the integrity of the site is maintained and that it makes the best possible contribution to maintaining Favourable Conservation Status (FCS) for Harbour Porpoise in UK waters</p> <p>In the context of natural change, this will be achieved by ensuring that:</p> <ol style="list-style-type: none"> 1. Harbour porpoise is a viable component of the site; 2. There is no significant disturbance of the species; and 3. The condition of supporting habitats and processes, and the availability of prey is maintained. <p>This is similar to the protection afforded to harbour porpoise throughout their range by the European Protected Species (EPS) regulations in the UK. However, the Natura 2000 principles and HRA tests set the bar higher than EPS protection for impacts on the site as the protection is no longer solely considering effects on the population as a whole but making sure that the site is contributing positively to the species' Favourable Conservation Status.</p>	<p>This site was fully designated in February 2019. Harbour porpoise could be affected by offshore wind development in the area, mainly through acoustic impacts (disturbance and hearing damage) from pile driving, UXO clearance and possibly some geotechnical surveys. Disturbance and barrier effects arising from vessel movements and presence of turbines may also occur.</p> <p>The noise disturbance during wind farm construction is likely to be significant if using pile-driving to install the turbine foundations, and there is also a risk from UXO clearance. There will be a need to consider population level effects of disturbance (mainly during construction), and there may be some additional requirements to investigate potential impacts on prey species.</p> <p>The designation of harbour porpoise SACs will undoubtedly have consequences as to how some activities operate, and measures may need to be put in place to reduce disturbance. Implementation of any disturbance management is likely to be challenging given the complexity of marine activities, regulatory arrangements and scientific uncertainty surrounding the significance of noise impacts on harbour porpoise. The approach recommended by SNCBs is that developers should ensure that there is sufficient time between the assessment and the start of construction for them to effectively implement mitigation/management, which could include:</p> <ol style="list-style-type: none"> 1. Careful spatial planning and phasing of noisy activities. 	Yellow	Yellow

					<p>2. Use of alternative foundations that do not require pile driving (e.g. suction buckets, gravity bases), noting that these may have other impacts.</p> <p>3. Use of alternative methods of installation (e.g. vibropiling) to reduce the noise footprint.</p> <p>4. Use of technology to reduce the sound levels at source or to minimise sound propagation and reduce the noise footprint.</p> <p>Harbour porpoise occur in elevated densities in some parts of the site compared to others during summer and winter. This may make mitigation slightly easier since summer is likely to be the most important construction season.</p> <p>The SNCBs and The Wildlife Trusts have concerns over the potential cumulative impacts on harbour porpoise within this SAC and note that currently there is no mechanism to ensure that a strategic approach to the management of impacts is taken. They consider that this could be a significant consenting risk for offshore wind development in the North Sea characterisation areas.</p> <p>In parallel to new offshore wind leasing, The Crown Estate has committed to fund a collaborative programme of strategic enabling actions to increase the evidence base and support sustainable and coordinated expansion of offshore wind. Underwater noise and its management, assessment of impacts on sensitive receptors, and approaches to modelling and assessment, are all likely to form a key priority area for further work, and we anticipate collaborating with stakeholders on new work streams under the programme to help address outstanding evidence gaps.</p>		
	Sites of Community Importance (SCIs)	None within the trigger distance					
	Ramsar	None within the trigger distance					
	Special Protection Areas (SPAs)	Outer Thames Estuary	red-throated diver (wintering) common tern (Breeding) and little tern (Breeding)	Maintain/restore red throated diver, common tern and little tern populations/distribution and supporting habitats.	<p>This site contains 38% of the British wintering population of red-throated diver. The presence of this SPA and the sensitivity of the red-throated diver offshore wind development/operation was the main reason why London Array II did not get consent – this should therefore be considered a significant constraint for further offshore wind development in the area. It is noted however that the characterisation area excludes the majority of the SPA area which should go a long way to avoiding (or reducing) impacts on red-throated diver and should make the potential impact mitigable.</p> <p>Collision impacts on tern species will need to be taken into consideration for development within the characterisation area. Cable construction/vessel movement is also likely to be an important constraint even if offshore wind development avoids the SPA. This may be manageable with agreed best practice measures or mitigation. It should be noted that whilst the current Natural England advice is to use a 4 km buffer for red-throated diver, there is evidence of red-throated diver displacement from activity up to 12 km away.</p>		

					<p>Royal Society for the Protection of Birds (RSPB) consider that red-throated diver at this site are very sensitive to offshore wind activity and the site should be considered a significant consenting risk.</p> <p>Both Natural England and JNCC have expressed a view that as a result of cumulative impacts from existing and consented offshore wind projects, adverse effects on integrity of red-throated diver from this site from future developments cannot be ruled out.</p>		
SPA	Greater Wash	<p>red-throated diver (Non-breeding)</p> <p>common scoter (Non-breeding)</p> <p>little gull (Non-breeding)</p> <p>Sandwich tern (Breeding)</p> <p>common tern (Breeding)</p> <p>little tern (Breeding)</p>	<p>SPA objectives:</p> <p>Protect wintering populations of red-throated diver, common scoter & little gull</p> <p>Protect feeding waters of breeding common, sandwich & little tern.</p>	<p>Classified as a SPA March 2018. The species which form part of the designation are sensitive to offshore wind through disturbance and collision. Red-throated diver and common scoter are sensitive to displacement from both OWF areas and cable construction. Little gull is sensitive to collision. Terns are potentially sensitive to some impacts associated with cable installation and are also sensitive to collision. Impacts on these populations could make consenting offshore wind projects highly problematic. It is noted however, that the majority of the SPA has been excluded from the characterisation area, which should greatly reduce the level of impact on the birds and make impacts mitigable (if not avoidable).</p> <p>RSPB consider that red-throated diver and common scoter at this site are very sensitive to offshore wind activity and the site should be considered a significant consenting risk.</p> <p>RSPB, Natural England and JNCC consider that offshore wind development in the North Yorkshire Coast, Wash and Southern North Sea characterisation areas could have impacts on this SPA.</p> <p>The SPA covers the areas of highest density foraging for sandwich tern from the North Norfolk Coast SPA. Natural England have advised that the distribution of sandwich tern extends beyond the SPA boundary and developments in this region may still have impacts on them. Refer to Wilson et al 2014: Quantifying usage of the marine environment by terns <i>Sterna</i> sp. around their breeding colony SPAs. JNCC Report No. 500</p>			
Marine Conservation Zones (MCZs)	Orford Inshore			Assessed as low risk; details available in separate spreadsheet.			
Sites of Special Scientific Interest (SSSIs)	None within the trigger distance.						
Spawning and nursery grounds	<p>There are few overlaps of high-intensity nursery and spawning grounds in the area (maximum is three). The most species overlaps occur to the west of the area.</p> <p>There is a herring spawning ground which overlaps with the southern corner of the characterisation area and another very close to the western edge. There is a Cod spawning area that intersects the south-eastern portion of the area.</p>			Noise disturbance has the potential to be an issue with the potential for seasonal restrictions on piling during breeding. It will depend on the precise locations of spawning grounds and whether they are still active (which may need to be determined by surveys). Cod is particularly sensitive to noise impacts.			

Social tier				
Royal Yachting Association (RYA) Automatic Identification System (AIS)	There is an area of significant recreational vessel traffic running to the east of the area up the Suffolk and Norfolk coasts.	The interaction between this activity and the area is minimal and therefore does not pose a significant constraint.		
Marinas	None within the trigger distance.			
Bathing beaches	None within the trigger distance.			
Visibility from sensitive receptors	See visual analysis below.			

Review layers

Visibility from landscape designations and from the coast

The bands of significant visual impact are taken from the OSEA3¹ environmental report. It should be noted that these bands were challenged through the statutory stakeholder engagement by the Statutory Nature Conservation Bodies (SNCBs) so further analysis and engagement should be conducted to understand the visual constraint in potential development areas more fully.

The visibility from landscape designations analysis has been conducted using designations which include protections for landscapes and settings namely: National Parks, Areas of Outstanding Natural Beauty (AONBs), Heritage Coasts and World Heritage sites. For more information on these, please consult the methodology report. The analysis draws on visibility from these designations but not the sensitivity of them to offshore wind developments. Proposals should draw on the relevant management plans or local policies to fully understand the level of constraint that exists in the vicinity of these landscape designations. As such, more analysis is required to fully understand the potential constraint.

	Band of significant visual impact	% of overlap with the characterisation area	Commentary	Area rating
Medium sensitivity receptors	0-13 km (3.6 MW turbines)	1%	There is a small proportion of this area that sits in a band of significant impact, however, 89% of the area is more than 30 km from shore. This means that although there may be some impact in specific areas, much of the area is relatively free from constraint.	
	13-20 km (4-8 MW turbines)	5%		
	20-30 km (10-15 MW turbines)	13%		
High sensitivity receptors	0-30 km	18%		

Visibility of sea surface from landscape designations		Receptor rating	Area rating
<p>The west of the characterisation area is relatively visible from</p> <ul style="list-style-type: none"> Suffolk Heritage Coast Suffolk Coast and Heaths AONB The Broads Authority 	<p>The visible part of this area is small in comparison to the characterisation area as a whole however, impacts within these areas of constraint will potentially be difficult to mitigate. There is significant opportunity elsewhere in the characterisation areas to allow appropriate siting to avoid impacts.</p> <p>The local planning authorities (Suffolk County Council, Suffolk Coastal District Council and Waveney District Council) have concerns over the impacts of turbine visibility from development within the area (particularly within 13 km of the shore, and in light of existing and planned offshore wind developments in the area). Impacts on seascape should be considered as part of the impacts on the AONB and Heritage Coast, since the undeveloped character of the seascape contributes to the setting of these designations. There are also concerns over the potential impact of visible turbines on tourism along the coast. The local planning authorities consider that significant and/or strategic mitigation measures will need to be included in project designs in order to enable acceptable developments within this characterisation area.</p> <p>The local planning authorities and other consultees have also expressed concerns about the visual impacts of onshore infrastructure associated with OWF development within this area and note that there are limited options for cabling landfall sites away from protected areas. They consider that onshore impacts of development within the characterisation area may be more significant than offshore impacts. There are already a number of existing and planned onshore structures in the Sizewell area which are affecting the AONB, including Sizewell A, B and C, and substations for Galloper, Greater Gabbard, East Anglia ONE North and East Anglia TWO offshore wind projects (and potential extensions to Galloper and Greater Gabbard). In addition to landscape designations, there are many other valued (and un-urbanised) landscapes along the coast including rural river valleys, historic parks and gardens, coastal, estuary and heathland areas, and significant concern over the sensitivity of these landscapes to cable landfall and grid connection</p>		

¹ BEIS (2016), OSEA3 Environmental Report. Crown copyright 2016, p 291. URN 16D/033.

infrastructure has been expressed. The flat nature of the landscape should also be taken into consideration in terms of the visibility of structures and the potential impacts on cultural heritage assets.

Ornithology outside of Special Protection Areas (SPAs) for high-risk species

Joint Nature Conservation Committee (JNCC), Natural England and Royal Society for the Protection of Birds (RSPB) advise that there are a number of information sources which should be taken into consideration in the assessment of potential impacts from offshore wind development in this characterisation area. These are:

- Site Information Centres on the JNCC website (<http://jncc.defra.gov.uk/page-6895>) which provide up-to-date information on protected areas, their features and status.
- Marine Ecosystems Research Programme (MERP) seabird distribution maps (https://marine-ecosystems.org.uk/Research_outcomes/Top_predators).
- Future of the Atlantic Marine Environment (FAME) and Seabird Tracking and Research (STAR) tracking data from the RSPB (<https://rspb.maps.arcgis.com/apps/Cascade/index.html?appid=d6c3aa1ec7184a2895a01cebf451c7b3>).
- Wakefield, E., Owen, E., Baer, J., Carroll, M., Daunt, F., Dodd, S., Green, J., Guilford, T., Mavor, R., Miller, P., Newell, M., Newton, S., Robertson, G., Shoji, A., Soanes, L., Votier, S., Wanless, S. & Bolton, M. (2017) Breeding density, fine-scale tracking, and large-scale modelling reveal the regional distribution of four seabird species. *Ecological Applications* <https://doi.org/10.1002/eap.1591>.
- Cleasby, I.R., Owen, E., Wilson, L.J., Bolton, M. (2018) Combining habitat modelling and hotspot analysis to reveal the location of high-density seabird areas across the UK: Technical Report. RSPB Research Report no. 63.
- Kober, K., Webb, A., Win, I., Lewis, M., O'Brien, S., Wilson, L.J., Reid, J.B. (2010) An analysis of the numbers and distribution of seabirds within the British Fishery Limit aimed at identifying areas that qualify as possible marine SPAs. JNCC Report 431 (and the distribution maps therein) (<http://jncc.defra.gov.uk/page-5622>).
- Sansom, A., Wilson, L.J., Caldow, R.W.G. & Bolton, M. 2018. Comparing marine distributions maps for seabirds during the breeding season derived from different survey and analysis methods. *PLOS ONE* <https://doi.org/10.1371/journal.pone.0201797>.
- Bradbury, G., Trinder, M., Furness, B., Banks, A.N., Caldow, R.W.G. & Hume, D. 2014. Mapping Seabird Sensitivity to Offshore Wind Farms. *PLoS ONE* 9(9): e106366. doi:10.1371/journal.pone.0106366.
- Thaxter, C.B., Ross-Smith, V., Bouten, W., Clark, N., Conway, G., Rehfish, M. & Burton, N. (2015) Seabird–wind farm interactions during the breeding season vary within and between years: A case study of lesser black-backed gull *Larus fuscus* in the UK. *Biological Conservation* 186: 347-358.

Species	Site	Commentary on coverage	Area rating
Gannet	Flamborough and Filey Coast (FFC) SPA	<p>The gannet mean maximum seaward foraging range extends 229 km from the source colony at FFC SPA. This range encompasses five other characterisation areas in addition and overlaps the north-western edge of the East Anglia characterisation area, which lies in the southeast of the foraging radius. As a result, cumulative collision risk effects should be considered if development is taken forward in more than one characterisation area. This cumulative effects constraint will also be affected by planned developments within the foraging range, e.g. Hornsea Project Three, Norfolk Boreas and Norfolk Vanguard West developments.</p> <p>Summer density decreases further offshore and to the east and south of the FFC SPA. The East Anglia characterisation area overlaps an area of slightly increased gannet density. However, although cumulative impacts on gannet will be a key HRA consideration for development in the East Anglia characterisation area, given the existing wind farm development within the FFC SPA gannet foraging range and wider North Sea, any impacts arising from development in the East Anglia area are likely to be manageable given the distance from the colony. Locating any development further south and east in the East Anglia area, beyond the FFC mean maximum foraging range (i.e. > 229 km) will help further reduce this consent risk.</p>	High
Herring gull	Alde-Ore Estuary SPA	<p>The herring gull mean maximum seaward foraging range extends 61 km from the Alde-Ore Estuary SPA, with the south-western part of the East Anglia characterisation area overlapping this foraging range. Given the existing offshore wind development within this foraging range and within the maximum range (92 km), cumulative impacts of development within the East Anglia area with other offshore wind development are likely to be a consent consideration.</p> <p>Summer density of herring gull within its foraging range is generally low, with some slightly increased density concentrated along the coast extending either side of the colony; this slightly increased density moves further offshore in the north of the foraging range. Locating any development in the East Anglia area further offshore and the east, beyond the maximum herring gull foraging range (i.e. > 61 km), will help minimise any impacts on this SPA colony.</p>	High
Lesser black-backed gull	Alde-Ore Estuary SPA	<p>The lesser black-backed gull mean maximum seaward foraging range extends 141 km from the Alde-Ore Estuary SPA, with the majority of the characterisation area encompassed within this foraging range. Given the high level of existing offshore wind development within this foraging range, cumulative impacts of development within the East Anglia characterisation area with other offshore wind developments are likely to be a consent consideration. Cumulative impacts will also be affected by planned developments within the foraging range i.e. Norfolk Boreas, Norfolk Vanguard, and Thanet Extension.</p>	Medium

		<p>Summer density of lesser black-backed gull is relatively high, with patches of highest density concentrated along the coast extending either side of the colony, and just to the south of the East Anglia area. Locating any development in the East Anglia area east and north away from the Alde-Ore Estuary SPA would help minimise any impacts on this SPA colony.</p> <p>RSPB have concerns over the potential for significant cumulative impact on lesser black-backed gull from the Alde-Ore Estuary SPA, especially in the light of existing and potential offshore wind development in the area. They are concerned that mitigation measures proposed for the Galloper offshore wind farm have not yet been successfully implemented.</p> <p>Natural England note that there is a significant amount of information to inform cumulative impacts on lesser black-backed gull at project level. This includes Thaxter <i>et al.</i> 2015 and lesser black-backed gull tracking data collected by RSPB and BTO (https://www.bto.org/science/migration/tracking-studies/tracking-lesser-black-backed-gulls).</p>	
Sandwich tern	Alde-Ore Estuary SPA	<p>The sandwich tern mean maximum seaward foraging range extends 49 km from the Alde-Ore Estuary SPA, with the south-western part of the East Anglia characterisation area overlapping this foraging range. Given the relatively restricted foraging range of the species and limited overlap with the characterisation area, cumulative impacts of development here with other offshore wind development are likely to be less of a concern than with other sandwich tern colonies.</p> <p>Summer density of sandwich tern is relatively uniformly distributed across the Alde-Ore foraging range, with a slightly higher density following the coast and extending to the offshore area by 18-35 km. Locating any development in the East Anglia characterisation area to the north and east and further offshore, beyond the foraging range of sandwich tern (i.e. > 49 km), would help minimise any impacts on this species.</p> <p>RSPB consider that post-consent monitoring data for sandwich tern from Dudgeon should be used in considering cumulative impacts.</p>	

Ministry of Defence (MoD) activity

	Issues when using 250 m tip heights	Issues when using 350 m tip heights	Receptor rating
Air traffic control (ATC)	No ATC concerns.	No ATC concerns.	
Air defence radar (ADR)	Trimingham ADR concerns.	Trimingham ADR concerns.	
Threat radar	No threat radar concerns.	No threat radar concerns.	
Low flying	No low flying concerns, however, there will be a lighting requirement.	No low flying concerns, however, there will be a lighting requirement.	
Ranges, danger and exercise areas	UXO should be taken into account. The MoD would need to review cable routes to ensure highly surveyed routes are not obstructed by cables or turbines.	UXO should be taken into account. The MoD would need to review cable routes to ensure highly surveyed routes are not obstructed by cables or turbines.	
Area commentary			Area rating
Significant ADR concerns at both tip height scenarios. The cumulative impact of several developments in the area will likely make mitigation of impacts difficult.			
There will be a lighting requirement and consideration of UXO as per standard industry practice.			

Fishing activity

Gear type	Location and comments	Area rating
Mobile gear	<ul style="list-style-type: none"> The area is a prime fishery for Dutch and Anglo-Dutch beam trawlers (mostly targeting sole), and for Dutch seine netting vessels and Belgian bam and otter trawlers. Many of these vessels would be unable to operate within an offshore wind array. Inshore potting for crab, whelk and lobster is undertaken by small vessels. English vessels undertake lining up to 20 NM from the coast. There has been a significant investment by a Lowestoft company building new and purchasing good second-hand fishing vessels 12-15 m in size – most of which are fishing the English Channel at present. If the opportunity arose, they could return to the Southern North Sea which might result in inshore trawling returning to the Lowestoft area. National Federation of Fishermen's Organisation (NFFO) advise that cumulative and in-combination impacts from existing offshore wind projects and management measures associated with MPAs are a concern in this area. 	
Static gear	<ul style="list-style-type: none"> There is a local fleet at Lowestoft but this has reduced in size in recent years. These vessels generally target whitefish through lining and netting. This generally does not take place outside of 12 NM. 	
Area commentary		Area rating
Not significant effort this far from the coast. There will be some useful information in the East Anglia Zone Appraisal and Planning document (EA ZAP) documentation covering this area.		

Future oil and gas

Licensing round	Commentary	Receptor rating	Area rating
28 th and 29 th rounds – north of the area	Three new licence blocks were awarded via the 28 th Oil and Gas Authority (OGA) licensing round (Blocks 54/6b, 54/11b, 54/16) and five blocks from previous rounds remain under licence and are understood to be in development. The eight licence blocks do not overlap with existing platform buffers so could present a significant new constraint in the eastern part of the characterisation area.		
30 th round- central northern part of the area	In the 30 th offshore licensing round includes three blocks that overlap with the East Anglia characterisation area. They are located in the central northern part of the characterisation area and may present additional constraint. However, not all these applications will progress and not all will require platforms. We will continue to work with the OGA to monitor the progress of these applications.		

Marine Plans

East Marine Plan	Spatially explicit policies	Issues	Area rating
Aggregates	<p>AGG3: within defined areas of high potential aggregate resource, proposals should demonstrate in order of preference:</p> <ol style="list-style-type: none"> that they will not prevent aggregate extraction; how, if there are adverse impacts on aggregate extraction, they will minimise these; how, if the adverse impacts cannot be minimised, they will be mitigated; and, the case for proceeding with the application if it is not possible to minimise or mitigate the adverse impacts. 	<p>The characterisation area, particularly the western and southern extents, overlaps with the area of optimal aggregate resource area identified in the East Marine Plan. This is especially focused around the existing licenses off the Norfolk coast. Any new offshore wind development would need to consider impacts to the aggregates industry negotiation with the sector would be required.</p> <p>Whilst The Crown Estate leases/licences seabed for offshore wind and aggregate extraction it should be noted that aggregates tendering rounds currently run every two years, and so the requirement for liaison between industries will be ongoing.</p>	
Tidal energy	<p>TIDE1: in defined areas of identified tidal stream resource proposals should demonstrate, in order of preference:</p> <ol style="list-style-type: none"> that they will not compromise potential future development of a tidal stream project; how, if there are any adverse impacts on potential tidal stream deployment, they will minimise them; how, if the adverse impacts cannot be minimised, they will be mitigated; and, the case for proceeding with the proposal if it is not possible to minimise or mitigate the adverse impacts. 	<p>The western part of the characterisation area overlaps with the area of identified tidal stream resource in the East Marine Plan. The overlap is however very small and is not considered to be a significant concern for future offshore wind development.</p>	

Aquaculture	AQ1: within sustainable aquaculture development sites (identified through research), proposals should demonstrate in order of preference: <ul style="list-style-type: none"> a) that they will avoid adverse impacts on future aquaculture development by altering the seabed or water column in ways which would cause adverse impacts to aquaculture productivity or potential; b) how, if there are adverse impacts on aquaculture development, they can be minimised; c) how, if the adverse impacts cannot be minimised they will be mitigated; and, d) the case for proceeding with the proposal if it is not possible to minimise or mitigate the adverse impacts. 	There is a small area of overlap in the western part of the characterisation area with the optimum sites of aquaculture potential identified in the East Marine Plan. Given the overlap is small it is not considered to be a significant concern for future offshore wind development.	
Carbon Capture Storage (CCS)	CCS1: within defined areas of potential carbon dioxide storage, proposals should demonstrate in order of preference: <ul style="list-style-type: none"> a) that they will not prevent carbon dioxide storage; b) how, if there are adverse impacts on carbon dioxide storage, they will minimise them; c) how, if the adverse impacts cannot be minimised, they will be mitigated; and, d) the case for proceeding with the proposal if it is not possible to minimise or mitigate the adverse impacts. 	There is a small area of overlap in the northern part of the characterisation area with the areas of potential opportunity for CCS identified in the East Marine Plan. Given the size of the overlap is small it is not considered to be a significant concern for future offshore wind development.	
Ports and shipping	PS2: proposals that require static sea surface infrastructure that encroaches upon important navigation routes should not be authorised unless there are exceptional circumstances. Proposals should: <ul style="list-style-type: none"> a) be compatible with the need to maintain space for safe navigation, avoiding adverse economic impact; b) anticipate and provide for future safe navigational requirements where evidence and/or stakeholder input allows; and, c) account for impacts upon navigation in-combination within other existing and proposed activities. 	The characterisation area, particularly the western and southern extents, overlaps with the important navigation routes identified in the East Marine Plan. Any new offshore wind development would need to account for navigation routes when locating the project area.	

The Crown Estate key resource areas (KRAs) for other sectors

KRA category	Where	Commentary	Receptor rating	Area rating
Cables	Intersects a small proportion of the area to the west.	This KRA is significant in size due to the landing resource for cables generally dictated by the shortest distance between connection points. Due to the significant number of alternative options for landing cables, the risk of sterilising valuable resource is deemed to be minimal.		
Carbon Capture Storage (CCS) stores	Overlaps with an aquifer which is rated as limited.	These sites are not the most favourable in terms of development potential so present little constraint.		
CCS infrastructure	Wide coverage across the area.	This KRA is significant in size due to the opportunity for CCS infrastructure development generally dictated by the shortest distance between connection points. Due to the significant number of alternative options for landing CCS infrastructure, the risk of sterilising valuable resource is deemed to be minimal.		

Minerals	Slight coverage to the east of the area.	Important aggregate resource for London market, increasing in value as onshore aggregate reserves decrease. There is significant opportunity for offshore wind development across the rest of the area.		
Pipelines	No interaction.			
Sandscaping	Covers all the area inside 12 NM.	This KRA is significant in size due to the knowledge of potential sites and resources for sandscaping schemes not being well known currently. As such, significant conclusions cannot be drawn from this key resource area.		
Tidal range	No interaction.			
Tidal stream	Very slight interaction to the north-west of the area.	This overlap is slight and occurs in an area that currently has no development interest. There is also significant other opportunity across the wider characterisation area.		
Wave	No interaction.			

National Air Traffic Services (NATs) radar overlap

% Overlap with Primary Surveillance Radar assessment buffer (200 m turbines)	Commentary	Area rating
73.37%	Intersect throughout the area so a further risk assessment will be required with site-specific mitigation options only available rather than siting. This is compounded by the high number of other existing and planned developments in the area.	

Water Framework Directive (WFD)

% of the area covered	Spatial overlap with the area	Commentary	Area rating
No intersect			

Marine cultural heritage

Heritage asset type	Where?	Commentary on sensitivity from offshore wind development	Receptor rating
Maritime archaeology and wrecks	Significant potential throughout the characterisation area, but particularly those parts closer to the coast in the west, and in association with known and historic shipping routes and	Maritime archaeology including known wrecks represented by a physical asset on the seabed, historic losses of vessels where precise location is uncertain, and associated cultural material may all be affected by OWF development in the East Anglia characterisation area. There is potential for the recovery of remains from the earliest seafaring in the prehistoric period to the present day, although the potential for seafaring craft from periods of prehistory at greater distances offshore is somewhat limited (although not zero) due to the current capabilities of vessels. The area contains a number of wrecks and obstructions with the greatest concentration of known sites being in closer proximity to the coast and in association with a number of significant navigational hazards and sandbanks (i.e. Cross Sands). A large number of isolated finds of maritime archaeological material are noted in the area, owing much to the presence of a number of marine aggregate licence areas. As is	

	<p>sandbanks such as Cross Sands.</p>	<p>commonplace throughout UK waters, there is a particular dominance of steel and metal vessels from the 19th and 20th Centuries, and there are also a number of wrecks associated with 20th Century military activity and trade.</p> <p>The characterisation area is located along the East Coast War Channels (ECWCs), which were maintained and patrolled routes for civilian shipping between the Scottish border and the North Kent Coast, in operation during the First and Second World Wars. The characterisation area thus contains large numbers of heritage assets, both of known wreck sites and of documented losses associated with the ECWCs.</p> <p>Established procedures exist to ensure that any historic wrecks, both known and unknown, and associated remains, are identified as part of any proposed OWF development so any impacts can be mitigated and minimised.</p>	
Aviation archaeology	<p>There is high potential for recovery of remains throughout the characterisation area, particularly in closer proximity to the coast.</p>	<p>There is potential within the East Anglia characterisation area for the discovery of remains of crashed aircraft and associated cultural material from the birth of aviation at the start of the 20th century to the present. The greatest potential is associated with losses from the Second World War, owing to activity in the numerous airborne battles, and defence of strategic locations and vital shipping routes along the Norfolk and Suffolk coast that took place at this time. Several Royal Air Force (RAF) bases were located close to the characterisation area and the historic records and research indicates a number of aircraft losses from the Second World War in this area: 217 losses off the coast of Norfolk, and 73 off the coast of Suffolk. Finds of aviation archaeological material from the area have been reported owing to the presence of a number of marine aggregate licence areas. These finds include significant assemblages of aviation archaeological material likely representing a complete wreck at marine aggregate licence Area 430 in the south-east of the characterisation area. Finds have also been reported from other aggregate areas indicating the potential for recovery of more material of this type in the area.</p> <p>While existing standard mitigation measures may be utilised for specific projects in the area, further site-specific mitigation including excavation and recovery of significant remains that are encountered and where impacts are unavoidable may be required, although it should be noted that this is an extreme example and would only be undertaken following significant discussion with advisors and in rare cases where preservation <i>in situ</i> was not a feasible option.</p>	
Submerged prehistoric landscapes	<p>Potential across characterisation area with enhanced potential in areas close to geomorphological features such as paleochannels, including the Paleo-Yare catchment in the offshore area to the east of Yarmouth and already subject to development by the marine aggregate industry.</p>	<p>During periods of lower sea level caused by three major glaciations (the Anglian, Wolstonian and Devensian) the characterisation area would at times have been exposed and, when not covered by the contemporary ice sheet, there is potential for recovery of cultural material associated with these periods. During the Anglian glaciation, the study area would have been completely covered, however, the extent of the Devensian or Wolstonian ice sheets did not reach as far south. Therefore, it is likely that large parts of the characterisation area were continually exposed at this time. It is expected that any remains would be associated with geomorphological features such as palaeochannels and valleys, and the geological deposits from these periods. The valleys and terraces associated with the palaeochannels are thought to be the most likely sites where prehistoric artefacts and objects might survive.</p> <p>There is some potential for the survival of sediments and secondary context artefactual material in areas where glacial activity has not eroded earlier sedimentary deposits. The middle Palaeolithic archaeological potential of the area has been demonstrated through the recovery, and subsequent investigation of the paleo-yare catchment in the east of the characterisation area, associated with a large assemblage of Middle Palaeolithic flint artefacts and faunal remains that were recovered from marine aggregate Licence Area 240 in the Anglian region in 2007/2008.</p> <p>Following the retreat of the Devensian ice sheet (c. 13,000 BP) a lot of the area would have been an accessible and attractive habitat for our Late Upper Palaeolithic and Mesolithic ancestors. Significant deposits and possible finds may therefore be anticipated in association with the early Mesolithic channel systems and other geomorphological features that were present and exposed prior to marine transgression. Therefore, there is potential for remains from this period to be present and impacted by OWF development in the characterisation area. Established procedures exist to ensure that any submerged prehistoric landscapes, associated geographical and geomorphological features, and associated deposits, features and finds are identified as part of any proposed OWF development and impacts are mitigated and minimised.</p>	
Area commentary			Area rating
<p>There are extensive heritage assets and potential for recovery of further remains across the area, with particular concentrations of known wrecks and obstructions in closer proximity to the coast. The main issue for this area lies in the consideration of the cumulative impact of further wind development on the submerged prehistoric resources. Therefore, consideration needs to be given to the cumulative effects on this resource on a strategic level across the area.</p> <p>Strategic mitigation may include exclusion of certain parts of the characterisation area to minimise the cumulative effects of further wind development on submerged prehistoric resources, however, further research may be required to better understand the cumulative impacts of development on this receptor class.</p>			

Glossary of acronyms and abbreviations

ADR	Air Defence Radar
AONB	Area of Outstanding Natural Beauty
ATC	Air Traffic Control
CCS	Carbon Capture Storage
EA ZAP	East Anglia Zone Appraisal and Planning document
ECWCs	East Coast War Channels
EPS	European Protected Species
FAME	Future of the Atlantic Marine Environment
FFC	Flamborough and Filey coast
HRA	Habitat Regulations Assessment
JNCC	Joint Nature Conservation Committee
km	Kilometre
KRA	Key Resource Area
m	Metre
MCZ	Marine Conservation Zone
MERP	Marine Ecosystems Research Programme
MoD	Ministry of Defence
MPA	Marine Protected Area
MW	Mega watt
NATS	National Air Traffic Services
NFFO	National Federation of Fishermen's Organisation
NM	Nautical Mile
OESEA3	Offshore Energy Strategic Environmental Assessment 3
OFTO	Offshore Transmission Owners
OGA	Oil and Gas Authority
OWF	Offshore Wind Farm
PSR	Primary Surveillance Radar
Ramsar	Ramsar Convention on wetlands of international Importance especially as waterfowl habitat, also known as the 'Convention on Wetlands'.
RAF	Royal Air Force
RSPB	Royal Society for the Protection of Birds
RYA AIS	Royal Yachting Association (RYA) Automatic Identification System (AIS)
SAC	Special Area of Conservation
SCI	Site of Community Importance
SNCB	Statutory Nature Conservation Body
SPA	Special Protection Area
SSSI	Site of Special Scientific Interest
STAR	Seabird Tracking and Research
TWT	The Wildlife Trusts
UXO	Unexploded Ordnance
WFD	Water Framework Directive