Outer Dowsing Offshore Wind

Habitat Regulations Assessment

Part 7, Document 7.8.3, Appendix D

NIRAS Site Selection ANS AoS

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Offshore Wind Leasing Round 4

Appendix D - Round 4 Strategic Compensation – Artificial Nesting Structure Site Selection

The Crown Estate

Date: 19th December 2023

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Contents

1 Introduction

1.1.1 During the fourth meeting of the Offshore Wind Leasing Round 4 Plan (**"**Round 4**"**) strategic steering group for kittiwake compensation (the "Steering Group") on 25th April 2023, the attendees discussed the approach to selecting sites for artificial nesting structures ("ANS") as a strategic compensation measure for kittiwake. NIRAS (as technical advisors to The Crown Estate) presented site selection criteria, which covered both onshore and offshore locations (as described below). The criteria were developed to enable potential locations for an ANS to be ranked and were categorised as either 'critical' or 'aimed at optimising the success of the measure'. Criteria were refined from those used in previous offshore wind project ANSs, which were made publicly available as compensation measures. As a result, these criteria have undergone a detailed consultation process and were reviewed by Natural England and other stakeholders. This process ensures a strong foundation for determining suitable potential locations for kittiwake ANS.

1.1.2 The Steering Group reached a consensus that the criteria were appropriate and agreed to apply them to potential locations as part of the strategic measure planning. This document outlines the site selection process undertaken by NIRAS (on behalf of The Crown Estate) to determine ecologically beneficial locations to construct an ANS for breeding kittiwake in the North Sea.

2 Site Selection Process

2.1.1 The site selection process for an ANS has been undertaken via a Geographical Information System exercise where ecological criteria is a primary consideration. The location of an ANS in terms of proximity to productive foraging areas and avoiding competition with other existing seabird colonies while maintaining connectivity with existing breeding kittiwake colonies are the key factors to increase the chance of colonisation of a structure.

2.1.2 Considerable site selection work has been undertaken and presented in an offshore and onshore context by recent offshore wind farm compensation cases. Those of particular relevance are from Hornsea Four (Orsted, 2022) and Outer Dowsing (2023). The site selection methodology presented here builds on this work, using similar approaches.

2.1.3 To maximise the chances of success, an ANS must have the basic building blocks required for the formation of a new colony, these are a safe nesting environment within foraging range of a stable prey source. One of the most important factors in choosing an optimal location for an ANS is the availability of prey resources. Colonies are generally located where travel distances between breeding and foraging locations are reduced, enabling optimal foraging for central-place foragers (Sandvik *et. al.* 2016). However, the size and distribution of colonies also has the potential to influence prey availability, and can create areas where new colony formation is unlikely. Density dependent factors are important in driving colony foraging patterns of kittiwake (Wakefield *et. al.* 2017), and segregation between colony foraging areas is apparent at some colonies (Bolton *et. al.* 2020). Therefore, the size and proximity of neighbouring colonies is important in determining the intensity of potential intraspecific inter-colony competition and segregation in foraging areas (Bolton *et. al.* 2020). Social attraction and stimulation is also important for kittiwake. Prospecting birds are strongly attracted to sites where social cues indicate breeding conditions are optimal (i.e. areas where productivity is high). In terms of connectivity to existing colonies, kittiwake are not highly philopatric with only 11% returning to their natal colony to breed (Horswill and Robinson 2015). The majority (c. 89%) of first time breeders generally recruit to other colonies within 100 km of their natal colony, with the rest recruiting ether between 400-1000 km from the natal colony (Coulson 2011).

2.1.4 These considerations have formed the key foundations for building a strong approach to determining suitable ANS locations.

3 Selection Criteria

3.1.1 A limited number of Special Protection Areas ("SPAs") are present in English waters for kittiwake and as a consequence, on the east coast, almost all impacts from offshore wind farms ("OWFs") are apportioned back to the Flamborough and Filey Coast SPA. To maintain connectivity with this population, site selection is only considered for sites in English, North Sea waters. Offshore and coastal locations within 100 miles of the coast were considered with the primary focus on the following ecological factors. It is envisioned that this will be a multi-faceted process with technical factors considered (see next steps) once sites of high ecological suitability have been identified.

3.2 Proximity to foraging areas

3.2.1 One of the most important factors in choosing an optimal location for an ANS is the availability of prey resources. There are however considerable knowledge gaps surrounding the location, size and availability to kittiwake of their key prey resources, especially further into the offshore environment. Diet and habitat preference studies indicate there is variation in the importance of these factors across their range (Wilson *et. al.* 2021, Chivers *et. al.* 2012). The quantity of prey resources available to foraging breeding adult birds (i.e. numbers of breeding adults and chicks the resource can energetically support) is associated with a degree of uncertainty, but certain proxies have been agreed by the Steering Group on as the most likely indicators of favourable food resources – two of these proxies have been used in this exercise: the presence of tidal mixing fronts and forage fish distribution.

Within foraging range of physical descriptors of prey abundance and availability e.g. tidal fronts

3.2.2 A key environmental feature that has been identified as providing important foraging opportunities for kittiwake are fronts (Camphuysen *et. al.* 2005). In the UK and Dutch waters, the Flamborough Front appears to be a particular area of importance for kittiwake (Riddell and Davison-Smith, (2023)). Kittiwakes can only reach prey within the top metre of the water column, so they are often associated with hydrographic features such as shelf breaks and tidal fronts which concentrate prey near the water surface (Leopold, 1993; Skov and Durinck, 1998; Markones, 2007). Stratification of the water column and tidal currents running over uneven topography is thought to be important in creating surface aggregations of sandeels that kittiwakes can exploit (Embling *et. al.*, 2012). Though tidal fronts can vary significantly depending on oceanographic, meteorological and climatic drivers, identification of persistent fronts may provide a useful indication of prey availability.

3.2.3 Miller & Christodoulou (2014) produced maps identifying frontal locations which have been widely used in the recommendation of UK Marine Protected Areas, as a proxy for identifying regions with high pelagic diversity. These maps were used in the heat map production process to identify potential areas of high prey availability and appropriate foraging conditions for kittiwake.

Within foraging range of biological descriptors of prey abundance and availability e.g. sandeel habitat, or other proxies indicating high likelihood of prey availability

3.2.4 During the breeding season, kittiwake feed mainly on small pelagic shoaling fish; in UK waters these consist of energy-rich species such as sandeels, sprats and young herring. Sandeel are a key prey species for the seabirds in the North Sea and their abundance and size are strongly linked to breeding success in kittiwake (Lewis et. al. 2001). There is a degree of regional variability in kittiwake prey preferences (Chivers et. al. 2012, Bull et. al. 2004, Furness and Tasker 2000), therefore this criteria does not represent an absolute measure of likely prey availability.

3.2.5 Marine Scotland (Langton *et. al.* 2021) have recently produced verified distribution models for the lesser sandeel (*Ammodytes marinus*), with maps predicting the occurrence and likely density of sandeels in parts of the North Sea. The probability of presence of buried sandeel in the North Sea study region was used in the heatmap process to identify potential prey resources for kittiwake.

3.3 Proximity to existing kittiwake colonies

3.3.1 For colonial seabirds, proximity of conspecific individuals is a strong stimuli influencing nest site selection (Buxton et. al. 2020). The presence of other nesting birds breeding successfully provides information about local breeding conditions (e.g., abundant food, safe places to nest) (Forbes and Kaiser 1994, Kildaw *et. al*. 2005). Consequently, the presence of a colony may reliably indicate favourable conditions. Birds are likely to recruit to other colonies within 100 km of their natal colony therefore proximity to existing kittiwake breeding sites will be a key factor in ensuring colonisation for an ANS. Connectivity between colonies is important, however, the presence of a large number of birds may increase competition for food resources nearby. Exceptionally large colonies only occur where there is little or no suitable nesting habitat elsewhere within the foraging range of birds from that colony (Furness and Birkhead 1984). This implies that provision of ANS would be more likely to attract kittiwakes where competition for resources would be less than at large colonies (e.g. avoiding areas within foraging range of large colonies). Therefore this criteria was based on the proximity to existing 'small' colonies (<5,000 pairs), with higher value given to sites closer (likely to be within visual range) to existing colonies with decreasing value based on dispersal distances detailed in Coulson (2011).

3.3.2 NB. There are populations of kittiwake known to be breeding on North Sea oil and gas rigs within the search area (Orsted, 2022), however, the location of these rigs and population sizes of kittiwakes are not in the public domain so have not been included in this exercise. This information (or similar collected by other developers) could alter the scoring of some areas offshore to become more favourable for locating an ANS.

3.4 Avoidance of areas where intraspecific competition is likely to be high.

3.4.1 The size and distribution of colonies has the potential to influence prey availability, so can create areas where new colony formation is unlikely. Density dependent factors are important in driving colony foraging patterns of kittiwake (Wakefield *et. al.* 2017), and segregation between colony foraging areas is apparent at some sites (Bolton *et. al.* 2020). Therefore, the size and proximity of neighbouring colonies is important in determining the intensity of potential intraspecific inter-colony competition and segregation in foraging areas (Bolton *et. al.* 2020), especially in relation to the installation of a new colony. The size and stability of prey resources will be key to whether neighbouring colonies are able to share or segregate resources at sea. For example, Paredes *et. al.* (2014) found that foraging areas of adjacent kittiwake colonies were highly segregated close to the colonies, but shared foraging grounds existed at more remote oceanic locations. Density-dependent competition may drive segregation locally, but temporally stable areas of high productivity located further away may be able to support a greater number of birds, causing segregation to break down (Bolton *et. al.* 2020).

3.4.2 Predictive modelling informed by seabird tracking data has been used to map the key at sea hotspots (which are likely to be foraging areas) for kittiwakes in UK waters (Cleasby *et. al.* 2020; Wakefield *et. al.* 2017). These maps have been used to highlight areas where competition for food resources is likely to be most intensive with the heatmap criteria set up to avoid overlap of ANS foraging areas with the key foraging areas of existing North Sea colonies.

3.5 Likelihood of exchange with FFC population but avoiding direct competition for resources

3.5.1 Statutory stakeholders have previously agreed that ANS site selection should avoid the core foraging range distance from the Flamborough and Filey Coast ("FFC") SPA (55 km for kittiwakes (based on Woodward *et. al.* 2019)), whilst maintaining some connectivity with FFC SPA to allow colony interchange to be a possibility. Therefore, a criteria scoring highly for connectivity with FFC SPA population (i.e. Within 100 km (Coulson 2011)) but not overlapping with the mean (core) foraging ranges from the SPA was included.

3.6 Hard Constraints

3.6.1 There are constraints from existing infrastructure, including oil and gas platforms, cables and pipelines, aggregates, OWFs, protected monuments and protected wrecks where the seabed is already occupied and therefore cannot be built in this location. In addition, there are areas such as navigational channels, military areas and also some specific types of land use where it is not possible to build structures. These are deemed as hard constraints and are removed from the study area.

3.6.2 Based on previous site selection discussions for other projects & spatial planning the following data and buffers have been used:

- Off wind farm (OWF) +15km buffer (based on an arbitrary value)
- OWF-met equipment
- Wave & tidal +500m
- Cables & pipelines +500m buffer
- Aggregate extraction areas +500m buffer
- Wrecks +500m buffer
- Wreck exclusion zones
- Scheduled monuments
- World Heritage Site
- IMO major shipping channels +1km
- Oil & Gas structures+500m
- Carbon capture Storage +500m
- Evaporates licence areas +500 (none were found in the area)
- Offshore mining +500m
- Land use types which would most likely preclude ANS construction, specifically residential, military, cemetery, quarry and retail.

3.6.3 In addition, The Crown Estate hold commercially sensitive information which has been considered in the identification and refinement of the Area's of Search.

3.6.4 The following datasets were not freely and publicly available:

- Defence areas
- Anchorage areas
- Aquaculture licences

3.7 Designated sites

3.7.1 Marine Conservation Zones ("MCZs"), Special Areas of Conservation ("SACs") and SPAs are highlighted in the final heatmaps but could still be considered if good ANS locations exist within them, but where an ANS would not cause an adverse effect on designated or classified features.

4 Map creation

4.1.1 A map was created for each criteria described in Section 3 above, the spatial extent of the search area within each map was scored based on the classification bands outlined in Table 4.1, with certain criteria weighted more highly if deemed to be critical to success (opposed to those which would optimise success). Ecological considerations included in the process are presented within Figure 4.2 to Figure 4.4. Scores were weighted by importance with critical criteria scoring double that of optimising criteria. All maps were overlaid and scores were calculated (summed) for each 10 km^2 cells to give the final heatmap surface. Hard constraints were then overlaid and are presented on the final map (**Error! Reference source not found.**). The map is also presented as an interactive web map and can be accessed via https://experience.arcgis.com/experience/a39d5aff7316419cba9098b5b3156221.

4.1.2 The size of the identified Areas of Search ("AOS") are considered large enough to provide the flexibility required for ground conditions to ensure the structures can be suitably micro-sited and acquire the necessary site permits and licences.

Table 4.1 Details on site selection scoring criteria – Scores were weighted by importance with critical criteria scoring double that of optimising criteria. Foraging ranges used are based on Woodward et. al. 2019, colony interchange distances are based on information in Coulson 2011.

Criteria	Weighting	Score			
		++	+	-	--
Prey availability – proximity to fronts	Critical	Area is within mean foraging range (55 km) of a tidal front	Area is beyond mean foraging range but within mean-max foraging range (156 km) of a tidal front	Area is beyond mean-max foraging range (156 km) of a tidal front	No tidal fronts exist within max recorded foraging range (770 km) for the species.
Prey availability – proximity to sandeels	Critical	Area lies on an area with sandeel presence	Area is beyond mean foraging range but with-in mean-max foraging range (156 km) of sandeel areas	Area is beyond mean-max foraging range (156 km) of sandeel areas	No foraging areas likely to exist within max foraging range (770 km) of the site
Connectivity - Distance to existing colonies	Critical	Area is 0-5 km from a small (<5000 pairs) existing colony (close enough to be in visual range for social cues)	Areas between 5-100 km from an existing small colony (areas of high connectivity where interchange of birds is most likely based on distances stated in Coulson 2011[1])	Area between 100-900 km from any known breeding colonies (lower chance of colony interchange[1])	Areas beyond >900 km from any known breeding colonies (beyond the distance colony interchange is likely to occur[1])
Connectivity to FFC SPA but avoiding direct competition	Optimal	Areas within 100 km[1] of FFC SPA but beyond likely foraging overlap zone i.e. beyond mean foraging range but out with likely foraging	N/A	Area beyond 100 km of FFC SPA [1]	Areas within likely foraging overlap zone of FFC SPA i.e. within mean foraging range (55 km)

[1] Coulson (2011) examined ringing recoveries of kittiwake born in the UK and states "Peak of recoveries of kittiwake were within 100 km of their place of birth, and a second, smaller peak occurred between 400 and 900 km from the natal colony. With the only exception being two birds which were found beyond 1500 km (moving from the UK to Greenland)".

		overlap zone (between 55-100 km from FFC)			
Minimising competition for resources with existing colonies	Optimal	Areas beyond and within max curvature kernels from Cleasby *et. al.* 2020 Gettis Ord hotspots – Limited competition for resources	Areas between statistically significant areas and max curvature kernels from Cleasby *et. al.* 2020 Gettis Ord hotspots – some competition for resources	Areas within the 5% Gettis Ord bands Cleasby *et. al.* 2020 Gettis Ord hotspots – high competition for resources likely	Areas within the 1% Gettis Ord band Cleasby *et. al.* 2020 Gettis Ord hotspots - highest competition for resources likely

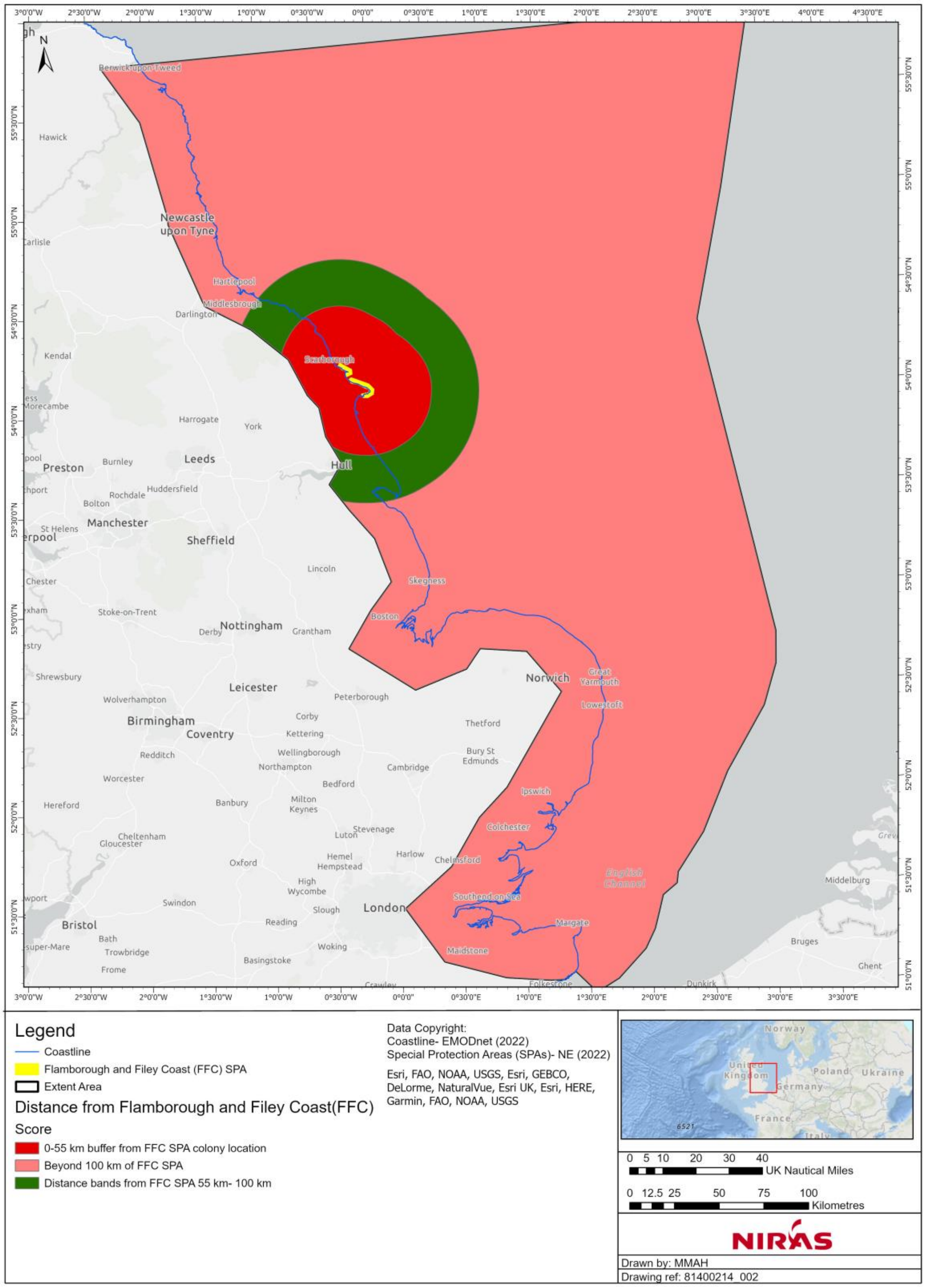

Figure 4.1: SPA connectivity and composition criteria map

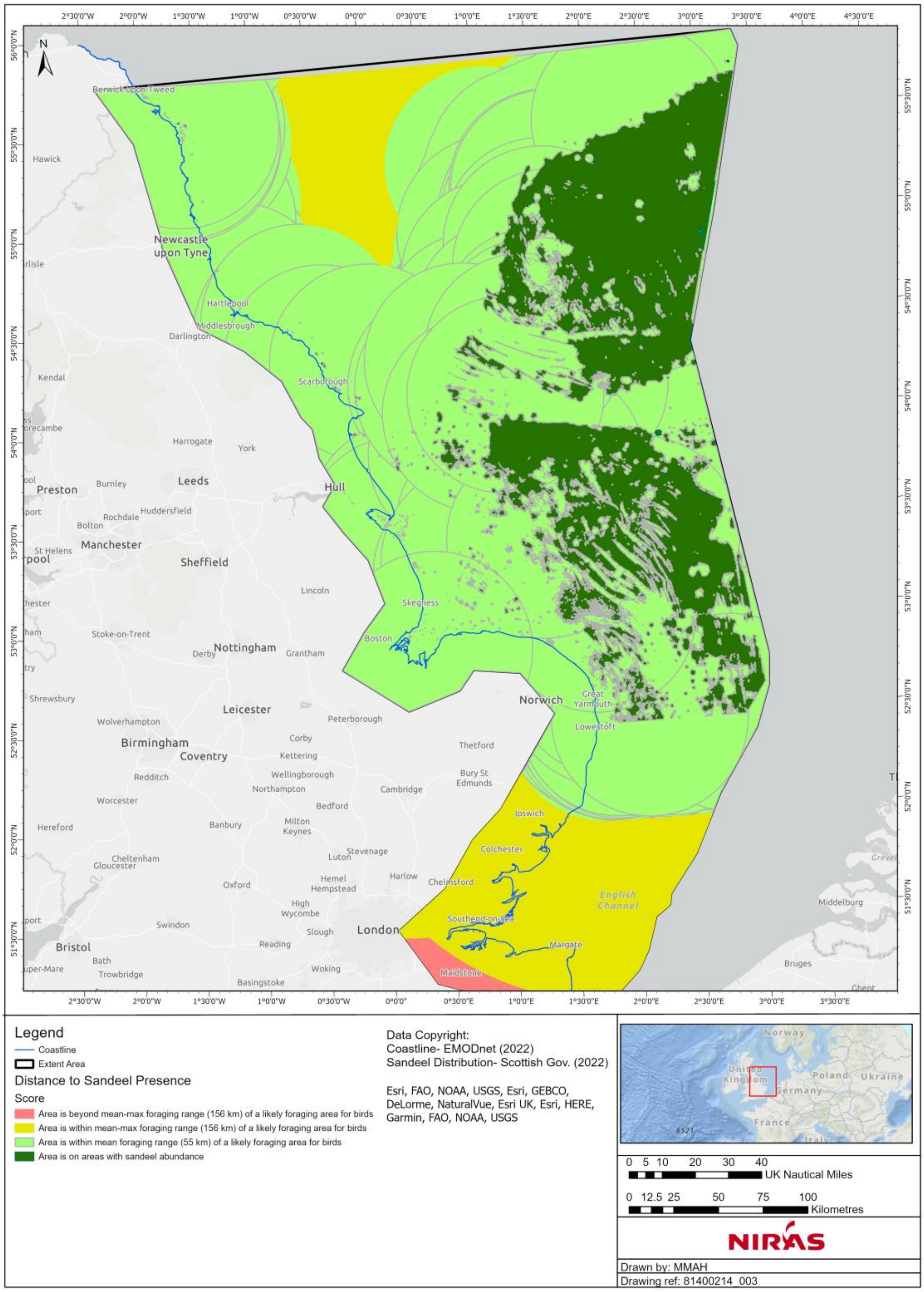

Figure 4.2: Sandeel availability criteria map

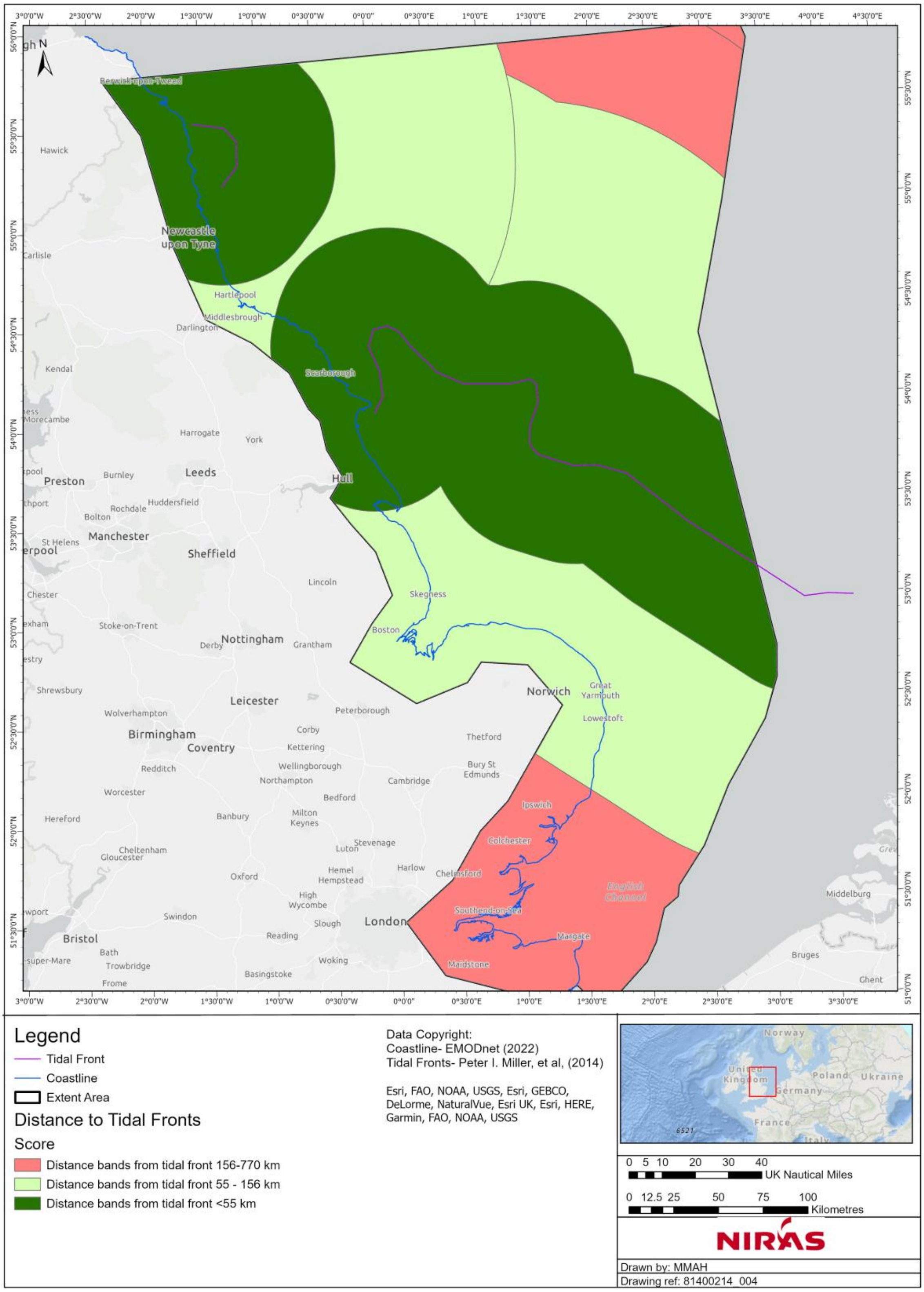

Figure 4.3: Prey availability criteria map

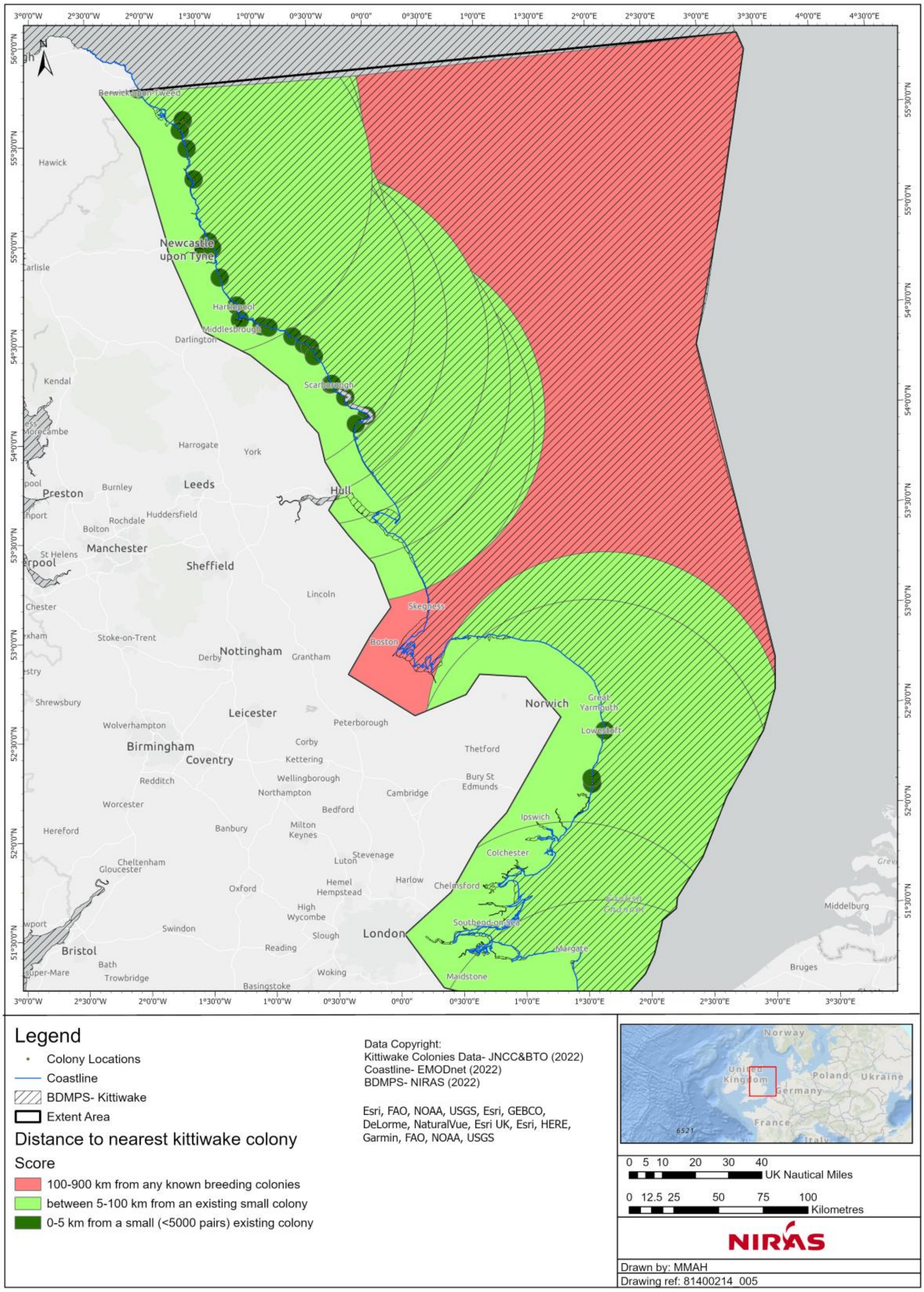

Figure 4.8: Connectivity and competition criteria map based on colony locations

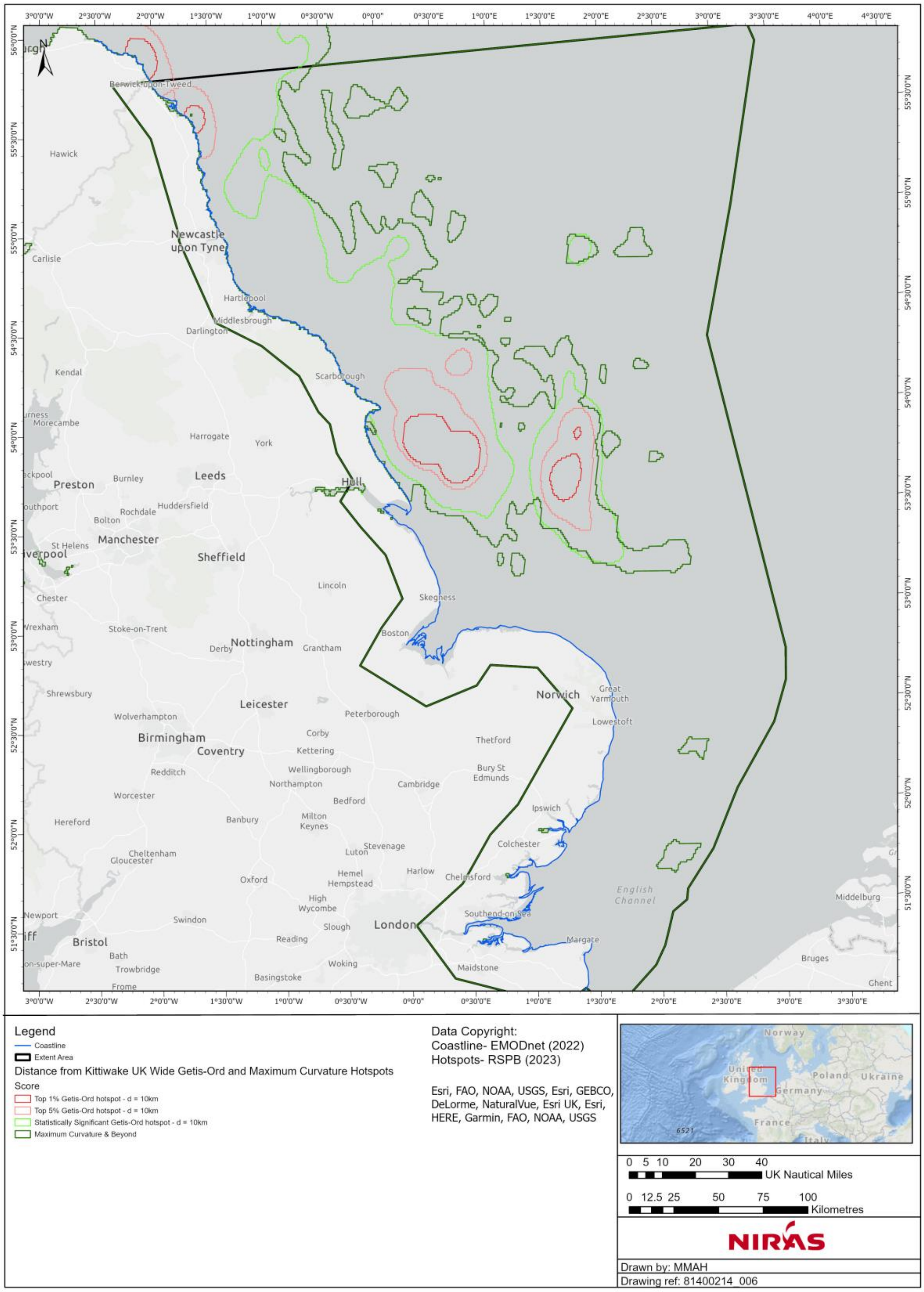

Figure 4.4: Connectivity and competition criteria map based on hotspots

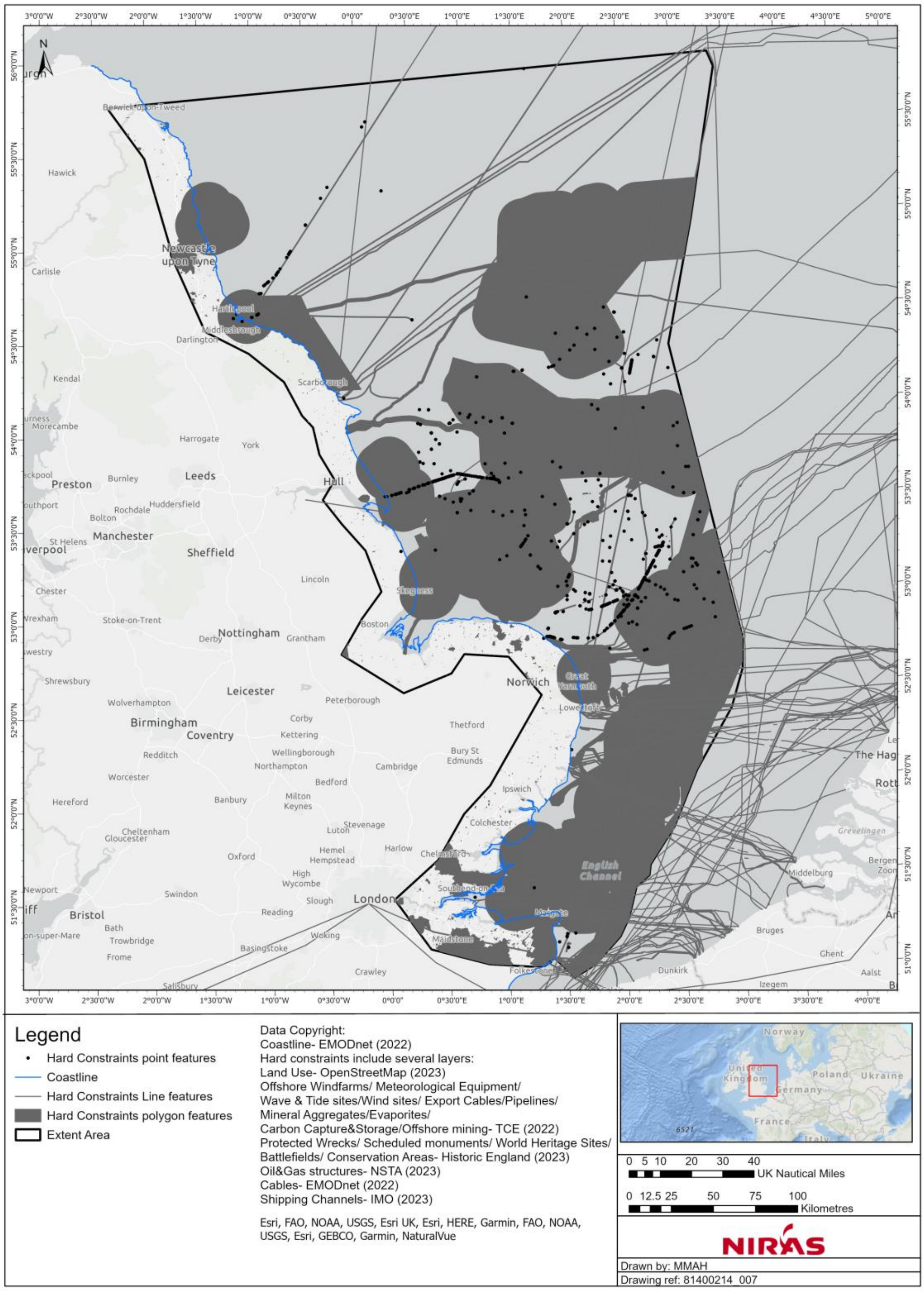

Figure 4.5. Hard Constraints

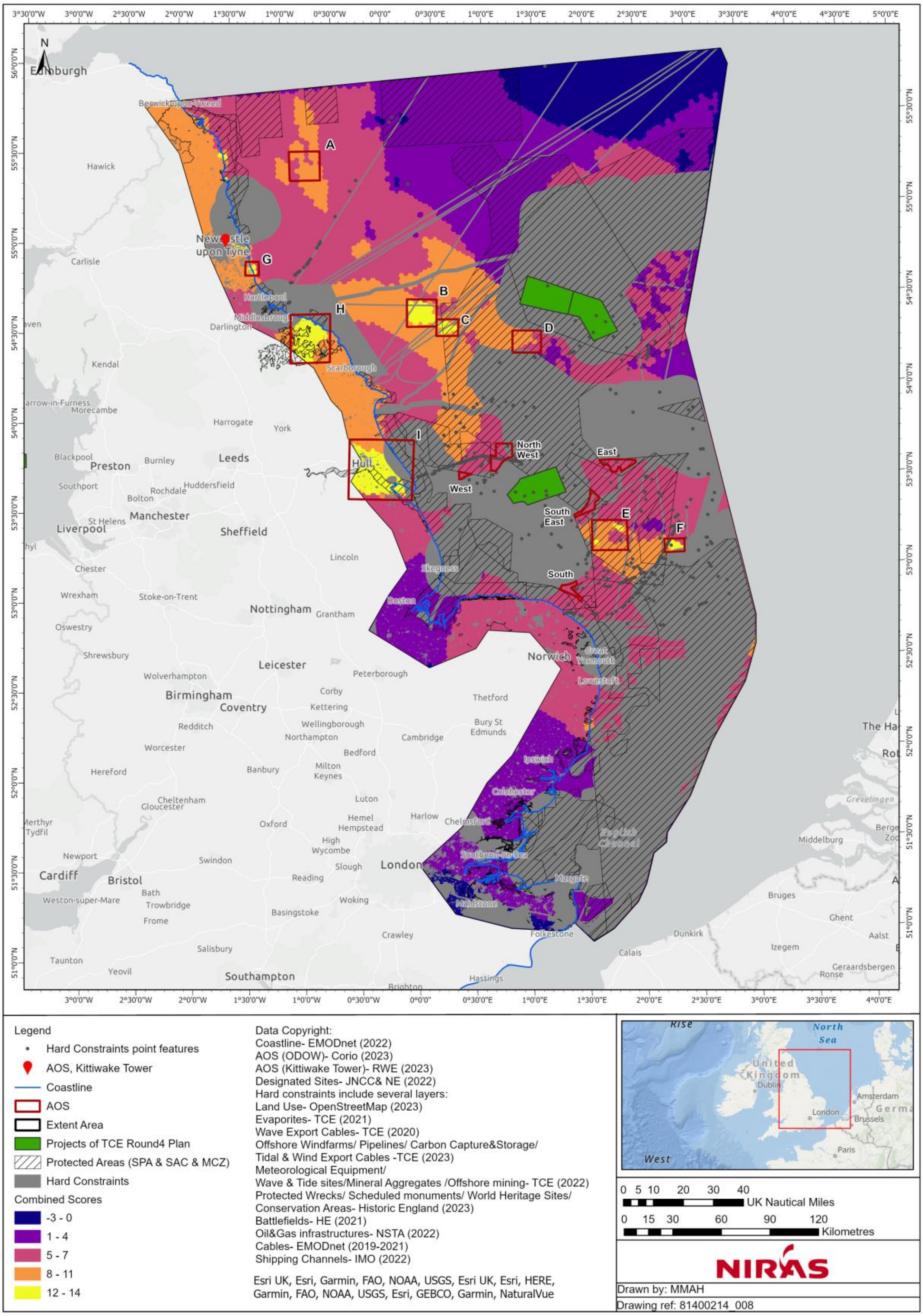

Figure 4.6. Final map of combined scores

5 Results

5.1.1 Following the application of the scoring criteria and hard constraints to the ecologically favourable areas, nine preferred areas were identified **Error! Reference source not found.**Figure 5.6). These nine areas, were then scored based on the existing comparative scoring criteria (presented in Steering Group meetings). There are no specific determinators between the way each site has been labelled (A-I). Economical and construction constraints should be considered at a later stage for these sites. This process should not rule out the further consideration of remaining areas as new information may become available in the future, which may make other areas suitable for an ANS delivered collaboratively or strategically with other parties.

Table 5.1 Scoring table with scores for each area based on agreed criteria

AOS	Overall score	Reasoning
A	20	Scores highly on proximity to potential food resources fronts, proximity to existing colonies may be closer than scored (due to presence of offshore colonies) but slightly further from sandeel abundance than other sites and outside area of likely interchange with FFC SPA.
B	27	Scores highly on proximity to potential food resources, may be closer than scored (due to presence of offshore colonies, however, these locations are not available in the public domain so could not be included in spatial analyses) but may be too close to existing colonies which could increase competition for food resources.
C	23	Scores highly on proximity to potential food resources, may be closer than scored (due to presence of offshore colonies, however, these locations are not available in the public domain so could not be included in spatial analyses) but may be too close to existing colonies which could increase competition for food resources.
D	25	Scores highly on proximity to potential food resources, may be closer than scored (due to presence of offshore colonies, however, these locations are not available in the public domain so could not be included in spatial analyses) but potentially close to offshore wind developments.
E	23	Scores highly on proximity to potential food resources, may be closer than scored (due to presence of offshore colonies, however, these locations are not available in the public domain so could not be included in spatial analyses) but outside area of likely interchange with FFC SPA and potentially close to offshore wind developments.
F	24	Scores highly on proximity to potential food resources, may be closer than scored (due to presence of offshore colonies, however, these locations are not available in the public domain so could not be included in spatial analyses) but outside area of likely interchange with FFC SPA and potentially close to offshore wind developments.
G	16	Good proximity to potential foraging areas but scored down on criteria/issues associated with being onshore e.g. coastal erosion and higher levels of human disturbance/conflict.

H	19	Good proximity to potential foraging areas but scored down on criteria/issues associated with being onshore e.g. coastal erosion and higher levels of human disturbance/conflict. Site close to areas where competition for prey is likely to be high.
I	1	Good proximity to potential foraging areas but scored down on criteria/issues associated with being onshore e.g. coastal erosion and higher levels of human disturbance/conflict Close to areas where competition for prey is likely to be high and further than the 100 km distance advised for connectivity with existing land-based colonies.

5.1.2 Apart from AOS 'I', all sites scored positively on the critical criteria. This uses only publicly available colony locations from the seabird monitoring program database, therefore there is the potential that all AOS may also be closer to existing colonies than the scores can reflect, e.g. there are kittiwake colonies on offshore structures which will likely mean there is more connectivity with existing colonies. All sites other than AOS 'I' score highly for ecological suitability so should be considered further. AOS 'I' has been excluded from further consideration.

6 Next steps

6.1.1 Now a 'long list' of areas of search have been identified via the NIRAS and developer-led approaches, the long list can be refined based on a number further criteria. As noted within the initial sections of this report, the site selection approach has been determined by ecological aspects. A potential barrier to the implementation of an ANS in an AOS may be as a result of hard constraints, such as shipping lanes etc.

6.1.2 Following discussion surrounding the suitability of onshore or offshore artificial nesting structures, the Steering Group decided to pursue offshore artificial nesting structures as a preference as a result of Steering Group discussions and the ecological evidence presented within the KSCP, and lack of certainty in the development of further onshore artificial nesting structures.

6.1.3 The next stage in the site selection process will be to apply additional shortlisting criteria as follows:

Additional soft constraints to be considered:

- SAC
- SPA
- MCZ
- Sites of Special Scientitific Interest ("SSSI")
- Ramsar sites
- Proximity to Areas of Outstanding Natural Beauty
- Disposal sites
- Shellfisheries classification areas
- Bathing waters
- Awarded Oil & Gas licence blocks
- Hydrocarbons fields
- Proximity Ports/ HA areas

- Shipping activity
- Tourism/ leisure activities
- Fishing grounds (in consultation with local fisherman)
- Nature reserves
- Historical conservation areas

To be considered during the refinement to a site within an AOS:
- Unexploded ordnance
- Engineering considerations (e.g. suitable ground/ seabed conditions, depths)
- Lease agreements
- Site access
- Land use plans/ spatial plans
- Flood risk/ coastal erosion (terrestrial locations)

7 References

Bolton, M., Conolly, G., Carroll, M., Wakefield, E.D. and Caldow, R. (2019), A review of the occurrence of in-ter-colony segregation of seabird foraging areas and the implications for marine environmental impact assessment. Ibis, 161: 241-259. https://doi.org/10.1111/ibi.12677

Bull J., S. Wanless, D.A. Elston, F. Daunt, S. Lewis & M.P. Harris (2004). Local-scale variability in the diet of Black-legged Kittiwakes Rissa tridactyla. Ardea 92(1): 43-52

Camphuysen, C. J., & de Vreeze, F. (2005). Black-legged Kittiwakes nesting on an offshore platform in the Neth-erlands. Limosa 78: 65–74.

Chivers L.S., Lundy M.G., Colhoun K., Newton S.F., and Reid, N. (2012). Diet of Black-legged Kittiwakes (Rissa tri-dactyla) feeding chicks at two Irish colonies highlights the importance of clupeids. Mar Ecol Prog Ser 56:269-277

Cleasby, I.R., Owen, E., Wilson, L., Wakefield, E.D., O'Connell, P. and Bolton, M. (2020). Identifying important at-sea areas for seabirds using species distribution models and hotspot mapping. Biological Conservation, 41, pp. 1-12.

Coulson, J.C. (2011). The Kittiwake. T. & A.D. Poyser, London.

Embling, C.B., Illian, J., Armstrong, E., van der Kooij, J., Sharples, J., Camphuysen, K.C.J. and Scott, B.E. (2012), In-vestigating fine-scale spatio-temporal predator–prey patterns in dynamic marine ecosystems: a functional data analysis approach. Journal of Applied Ecology, 49: 481-492. https://doi.org/10.1111/j.1365-2664.2012.02114.x

Forbes, L. S., & Kaiser, G. W. (1994). Habitat Choice in Breeding Seabirds: When to Cross the Information Barrier. Oikos, 70(3), 377–384. https://doi.org/10.2307/3545775

Furness, R.W. and Birkhead, T.R. (1984). Seabird colony distributions suggest competition for food supplies dur-ing the breeding season. Nature 311, 655-656

Furness, R. W., and Tasker, M. L. (2000). Seabird-fishery interactions: quantifying the sensitivity of seabirds to reductions in sandeel abundance,m and identification of key areas for sensitive seabirds in the North Sea.Ma-rine Ecology Progress Series, 202: 253–264

Horswill, C. & Robinson, R.A. (2015). Review of seabird demographic rates and density dependence, JNCC Re-port No: 552, JNCC, Peterborough, ISSN 0963-8901. Kildaw, S.D., Irons, D.B., Nysewander, D.R. & Buck, C.L. (2005). Formation and growth of new seabird colo-nies: the significance of habitat quality. Marine Ornithology 33: 49–58

Langton, R., Boulcott, P. and Wright P.J. (2021) A verified distribution model for the lesser sandeel Ammodytes marinus. Marine Ecology Progress Series. https://doi.org/10.3354/meps13693

Leopold, M.F. (1993). Seabirds in the shelf edge waters bordering the Banc d'Arguin, Mauritania, in May. In: Wolff, W.J., van der Land, J., Nienhuis, P.H., de Wilde, P.A.W.J. (eds) Ecological Studies in the Coastal Waters of Mauritania. Developments in Hydrobiology 86, vol 86. Springer, Dordrecht. https://doi.org/10.1007/978-94-011-1986-3_17

Lewis, S., Wanless, S., Wright, P.J., Harris, M.P., Bull, J. & Elston, D.A. (2001). Diet and breeding performance of black-legged kittiwakes Rissa tridactyla at a North Sea colony. Marine Ecology Progress Series, 221, 277–28

Markones N (2007). Habitat selection of seabirds in a highly dynamic coastal sea: temporal variation and influence of hydrographic features. Ph.D. thesis, University of Kiel.

Miller & Christodoulou (2014) Miller, P.I. & Christodoulou, S. (2014) Frequent locations of ocean fronts as an indicator of pelagic diversity: application to marine protected areas and renewables. Marine Policy. 45, 318–329, doi: 10.1016/j.marpol.2013.09.009.

Riddell, R., and Davison-Smith, H., (2023) 2022-2026 Flamborough Head European Marine Site Management Plan. Online at https://yorkshiremarinenaturepartnership.org.uk/wp-content/uploads/2023/02/22-12-19-2022-2026-FHEMS-Management-Plan-Full-Doc-FINAL.pdf [Accessed 24/07/2023]

Orsted, 2022 / Niras (2021). Hornsea Project Four: Derogation Information PINS Document Reference: B2.7.1 APFP Regu-lation: 5(2)(q) Volume B2 Annex 7. 1 Compensation measures for FFC SPA Offshore Artificial Nesting Eco-logical Evidence

Outer Dowsing (2023). Offshore Artificial Nesting Structures: Ecological Evidence and Roadmap. [online] Available at: https://www.outerdowsing.com/wp-content/uploads/2023/06/7.4_Offshore-Artificial-Nesting-Structures-Ecological-Evidence-and-Roadmap.pdf [Accessed 24/07/2023]

Paredes R, Orben RA, Suryan RM, Irons DB, Roby DD, Harding AMA, Young RC, BenoitBird K, Ladd C, Ren-ner H, Heppell S, Phillips RA, Kitaysky A (2014) Foraging responses of black-legged kittiwakes to prolonged food-shortages around colonies on the Bering Sea shelf. PLoS ONE 9(3):e92520

Sandvik, H., Barrett, R. T., Erikstad, K. E., Myksvoll, M. S., Vikebø, F., Yoccoz, N. G., AnkerNilssen, T., Lorentsen, S.-H., Reiertsen, T. K., Skarðhamar, J., Skern-Mauritzen, M. & Systad, G.H. (2016). Modelled drift patterns of fish larvae link coastal morphology to seabird colony distribution. Nature Communications 7: 11599.

Skov, H./ and Durinck J., (1998) Constancy of frontal aggregations of seabirds at the shelf break in the Skagerrak. Journal of Sea Research 39:305-311

Wakefield, E.D., Owen, E., Baer, J., Carroll, M.J., Daunt, F., Dodd, S.G., Green, J.A.,Guilford, T., Mavor, R.A., Miller, P.I., Newell, M.A., Newton, S.F., Robertson, G.S., Shoji,A., Soanes, L.M., Votier, S.C., Wanless, S. and Bolton, M. (2017). Breeding density, finescale tracking, and large-scale modeling reveal the regional distri-bution of four seabird species. Ecological Applications, 27(7), pp. 2074-2091.

Wilson, L.J., Owen, E., Hughes, R., Coledale, T. & Bolton, M. (2021) Geographic variation in black-legged kittiwake diet. Presentation at the 7th World Seabird Twitter Conference, 4 May 2021 [@lindajwilson9]
Woodward, I., Thaxter, C.B., Owen, E. and Cook, A.S.C.P. (2019). Desk-based revision of seabird foraging ranges used for HRA screening. Report of work carried out by the British Trust for Ornithology on behalf of NIRAS and The Crown Estate. BTO Research Report No. 724. Thetford, Norfolk.