Hornsea Project Four: Derogation Information

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Volume B2 Annex 7. 1 Compensation measures for FFC SPA Offshore Artificial Nesting Ecological Evidence

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Glossary

Term	Definition
Compensation / Compensatory Measures	If an Adverse Effect on the Integrity on a designated site is determined during the Secretary of State's Appropriate Assessment, compensatory measures for the impacted site (and relevant features) will be required. The term compensatory measures is not defined in the Habitats Regulations. Compensatory measures are however, considered to comprise those measures which are independent of the project, including any associated mitigation measures, and are intended to offset the negative effects of the plan or project so that the overall ecological coherence of the national site network is maintained.
Development Consent Order (DCO)	An order made under the Planning Act 2008 granting development consent for one or more Nationally Significant Infrastructure Projects (NSIP).
Habitats Regulations	The Conservation of Habitats and Species Regulations 2017 and the Conservation of Offshore Marine Habitats and Species Regulations 2017
Hornsea Project Four Offshore Wind Farm	The term covers all elements of the project (i.e. both the offshore and onshore). Hornsea Four infrastructure will include offshore generating stations (wind turbines), electrical export cables to landfall, and connection to the electricity transmission network. Hereafter referred to as Hornsea Four.
Orsted Hornsea Project Four Ltd.	The Applicant for the proposed Hornsea Project Four Offshore Wind Farm Development Consent Order (DCO).

Acronyms

Term	Definition
DCO	Development Consent Order
FFC	Flamborough and Filey Coast
JNCC	Joint Nature Conservation Committee
MMO	Marine Management Organisation
RSPB	Royal Society for the Protection of Birds
SPA	Special Protection Area

1 Summary

1.1 Background

1.1.1.1 This report reviews the evidence base on the potential for offshore artificial nest sites to increase the annual recruitment of black-legged kittiwake Rissa tridactyla (kittiwake) and northern gannet Morus bassanus into the regional population of the southern North Sea, which forms part of the wider Eastern Atlantic kittiwake population (**Sections 3.1** & **3.2**). The focus of this work is delivery of compensation for the Adverse Effect on Site Integrity at the Flamborough and Filey Coast Special Protection Area (FFC SPA) in relation to the proposed development of Hornsea Four Offshore Wind Farm (Hornsea Four) and its in-combination collision impact on kittiwake. Suitable at sea areas are identified where installation of or modification to existing structures could provide artificial nesting structures for kittiwakes (**Section 3.3**). Issues surrounding the potential impacts of the project are discussed (**Section 3.5**). Key design features are identified (**Section 3.6**) alongside calculations of potential population sizes they could support (**Section 3.7**). The applicability of this measure in relation to delivering on compensation objectives and identification of evidence gaps surrounding the issue are then discussed (**Section 3.8**).

1.2 Key findings

1.2.1.1 If the environmental conditions are favourable, birds will readily colonise offshore structures often within a few years of their construction. Birds began colonising oil and gas platforms in the 1990s and have continued to colonise new sites as recently as 2016.

1.2.1.2 There is a key knowledge gap surrounding the number of birds currently breeding on offshore structures. A census of the whole offshore kittiwake population would be beneficial to this project, and to the offshore wind industry as a whole.

1.2.1.3 Location in terms of proximity to key foraging areas such as tidal fronts is important to increase the chance of colonisation of a new structure.

1.2.1.4 The overall design of a structure can be flexible, as long as suitable narrow nesting ledges are present.

1.2.1.5 Offshore sites may provide a vital refuge to buffer against declining coastal populations, and provision of additional undisturbed nesting spaces could enable these populations to increase.

2 Introduction

2.1.1.1 Orsted Hornsea Project Four Limited (hereafter the 'Applicant') is proposing to develop Hornsea Project Four Offshore Wind Farm (hereafter 'Hornsea Four') which will be located approximately 69 km offshore from the East Riding of Yorkshire in the Southern North Sea and will be the fourth project to be developed in the former Hornsea Zone.

2.1.1.2 Hornsea Four will include both offshore and onshore infrastructure including an offshore generating station (wind farm), export cables to landfall, and connection to the electricity transmission network.

2.1.1.3 This document has been prepared to support the identification of compensatory measures for Hornsea Four and its potential impacts on black-legged kittiwake Rissa tridactyla (hereafter kittiwake) and northern gannet Morus bassanus (hereafter gannet). In light of the conclusions of the report to inform the appropriate assessment which will support the Hornsea Four DCO application, Hornsea Four's position is that no adverse effect on the integrity on the Flamborough and Filey Coast SPA will arise from Hornsea Four alone or in-combination with other plans or projects. Nevertheless, in light of the Secretary of State's clear direction in his decision letter for Hornsea Three, Hornsea Four's DCO application will be accompanied by a derogation case (including compensatory measures) which will be provided on a "without prejudice" basis i.e. the derogation case will be provided without prejudice to Hornsea Four's conclusion that no adverse effect on integrity will arise. An offshore repurposed structure is the Applicant's preferred measure to compensate for kittiwake and gannet, a new offshore nesting structure or an onshore structure is also considered as a compensation measure if deemed necessary by the Secretary of State. The purpose of this document is to explore the evidence base for the compensatory measure of offshore artificial nesting for kittiwake and gannet.

2.1.1.4 The purpose of this document is to explore the evidence base for the compensatory measure under consideration. Where evidence gaps are identified, Hornsea Four is working on a strategy to address those gaps which is to be finalised for DCO Providing additional nesting opportunities for kittiwakes could potentially enhance productivity and therefore be effective as a compensatory measure. Kittiwakes are known to nest successfully on man-made structures and have readily adapted to artificial nesting structures in onshore and offshore environments.

2.1.1.5 The merits of this compensatory measure have been discussed in detail during Hornsea project Three examination, details of which can be found within Orsted's 'Response to the Secretary of State's Minded to Approve Letter Annex 2 to Appendix 2 (Kittiwake Compensation Plan): Kittiwake Artificial Nest Provisioning: Ecological Evidence report' (Sept 2020).

2.1.1.6 The information presented in the evidence report for Hornsea Three largely focused on the delivery of additional nesting opportunities in an onshore environment (i.e. coastal location). The key findings of this report were broadly supported by SNCBs as an adequate compensatory measure. A Development Consent Order for Hornsea Three was received from the Secretary of State on 31 December 2020 with this compensation measure included as a condition.

2.1.1.7 The biological evidence supporting this measure is also applicable to the provision of artificial nesting structures located offshore. The ecological requirements identified which are likely to be important for the long-term establishment of a new colony onshore (e.g. proximity to food, lack of predation, low intraspecific competition, proximity to healthy seed populations) also apply offshore. Biologically, an offshore location may actually present fewer constraints to birds over a coastal location. However, similar issues raised around uncertainty remain, specifically, the size of the pool of available breeders which could colonise and breed successfully on structures.

2.1.1.8 This report considers the biological evidence relating to kittiwake colonisation of offshore structures. It also calculates a range of population sizes that could meet compensatory obligations (dependant on final agreed impact ranges and compensation being required for kittiwake) and explores which existing sites appear to be most appealing for birds and why.

2.1.1.9 In addition, there are three accompanying survey reports provided as appendices:

- 1) Survey Report from the June Boat Based Survey of nesting birds of oil and gas platforms in the southern north sea (**Appendix A**);
- 2) Survey Report from the July Boat Based Survey of nesting birds of oil and gas platforms in the southern north sea (**Appendix B**); and
- 3) Survey Report from the July aerial Survey of nesting birds of oil and gas platforms in the southern north sea (**Appendix C**).

3 Kittiwake

3.1 Evidence base for kittiwake propensity for colonising artificial nesting structures offshore in the North Sea and wider region

3.1.1.1 Kittiwakes do not seem to exhibit a preference between natural or artificial nesting sites (Coulson 2011). Man-made structures such as buildings and piers meet similar nesting requirements to natural nesting sites (i.e. vertical cliff faces with narrow ledges, close to the water) and have readily been adopted by kittiwakes in areas where natural breeding sites are in short supply (e.g. Coulson 2011, Hatch et al. 1993, Harris et al. 2019, Camphuysen & de Vreeze 2005, Camphuysen & Leopold 2007, Ponchon et al. 2017, Turner 2010). Offshore structures such as those used in the oil and gas industry also fulfil kittiwake nesting requirements and may provide an additional benefit as they are generally closer to potential foraging sites and further away from land based predators (Christensen-Dalsgaard et al. 2019).

3.1.1.2 The UK kittiwake population expanded rapidly during the late 60s to the mid-80s, through this period of expansion birds began breeding on man-made structures in urban coastal environments (Coulson 2011, JNCC 2020). However, since the 1990s the global kittiwake population has been decreasing rapidly, with an overall decline of 40% since 1975 (Descamps et al. 2017; BirdLife International 2018). Kittiwakes were first recorded breeding offshore on platforms in the Norwegian Sea in the early 1990s (Christensen-Dalsgaard 2019), and first bred successfully on an offshore structure in the UK at Morecambe Gas Platform (Irish Sea) in 1998 (Unwin 1999). During the early 2000s birds also colonised platforms in the Dutch North Sea and more platforms in the Norwegian Sea (see **Table 1**).

3.1.1.3 Despite population declines, it appears that kittiwakes are still colonising offshore structures, as has been documented in Norway. A study that approached operators of 63 offshore oil rigs on the Norwegian shelf (Christensen-Dalsgaard 2019) received confirmation that kittiwakes were breeding on six oil rigs (10%), 33 (52%) had no breeding kittiwakes (52%), and no information was received from the remaining 24 oil rigs (30%). All those platforms that acknowledged having breeding kittiwake were located in the Norwegian Sea or the Barents Sea (one platform). Population estimates were recorded for four of these offshore colonies, totalling 1,164 breeding pairs in 2019 (Christensen-Dalsgaard 2019). The kittiwakes breeding on man-made structures both offshore and on the coast provide a significant contribution of juveniles to the impoverished kittiwake population in Norwegian waters and suggest that offshore breeding sites may provide a vital refuge for the species as natural populations continue to decline (Christensen-Dalsgaard et al. 2019).

3.1.1.4 In the UK, coastal populations nesting in urban locations and on artificial structures seem to be stable or even increasing (JNCC 2020, Turner 2010 & 2018). Numbers are also thought to be increasing on offshore structures, with new structures being colonised as recently as 2016 (Christensen-Dalsgaard et al. 2019 & pers. comm., Camphuysen pers. comm.). A recent survey of a small sample of platforms in the UK southern North Sea found 1,394 breeding pairs (Orsted survey reports 2021 – **Appendix A**). It is highly likely that there are more offshore installations supporting breeding kittiwakes in European waters than are currently documented (see **Table 1**). There are in addition a number of Dutch and British platforms identified where birds have been seen prospecting or potentially breeding (see **Table 2**) but so far breeding has not been confirmed.

3.1.2 Orsted offshore kittiwake surveys in 2021

3.1.2.1 To increase the knowledge base surrounding the number and location of kittiwakes breeding on offshore installations in the UK southern North Sea, Orsted commissioned boat based and aerial surveys during the 2021 breeding season (see Orsted survey reports 2021 at Appendices A, B and C). A number of installations were surveyed for breeding kittiwake with the number of birds and nests (if present) recorded together with, at some of these occupied installations, breeding success (productivity).

3.1.2.2 To date information on kittiwake breeding presence has been established for 100 rigs in in northern European waters (Camphuysen et al. (2005), Camphuysen & Leopold (2007), Geelhoed et al. (2011), Christensen-Dalsgaard et al. 2019, Orsted survey reports 2021 – see Appendices: **Appendix A**, **Appendix B**, **Appendix C**). There are currently 26 known kittiwake colonies (where breeding has been confirmed) on offshore installations (). Nine of those installations in the southern North Sea were found by Orsted's boat based surveys to support a minimum of 1,500 breeding pairs (AONs). Kittiwakes have been recorded as present on at least another 12 installations, which may only have been roosting but on at least two installations breeding is suspected to occur (**Table 2**, **Figure 1**). In addition, a further 62 rigs surveyed (either partially of fully) are believed to have no longstanding kittiwake presence. To our knowledge, no cases of either kittiwake species (red-legged or black-legged) nesting on offshore structures outside of northern Europe have been documented.

3.1.2.3 Due to the nature of offshore installations they are difficult to access and survey for external personnel, as such, data on population trends are sparse (see section 4). Kittiwake have colonised structures with features and materials similar to offshore energy platforms in the nearshore environment - at Sizewell Rigs, Suffolk. Birds first colonised the site in 1994. n Numbers have since increased to 200 pairs by 2001 and 502 apparently occupied nests (AON) in 2008. However, the population is now thought to be space-limited and so is unlikely ever to exceed 500 pairs (McMurdo-Hamilton 2016). At Morecambe Gas Platforms, Lancashire, periodic counts have been undertaken since 2001 where the population was increasing (JNCC 2020). The most recent count in 2016, recorded a population increase to ca.150 nests on the central platform that was originally colonised with an additional ca.70

nests on the surrounding satellite platforms. This may indicate population size at the central platform has reached capacity, however, further surveys of the rig would be required to verify this.

3.1.2.4 Recent studies on birds nesting on offshore platforms off the Norwegian coast suggest breeding success may be higher at these locations than at natural sites (Christensen-Dalsgaard et al. 2019). Sites in the 'right' location for birds appear to be adopted readily and populations can increase rapidly to fill suitable nesting ledges, therefore, deployment of artificial nest sites offshore remains a viable compensatory option. However, more work is required to understand the potential implications, especially with regards to safeguarding against additional cumulative impacts occurring on kittiwake populations at Natura 2000 sites. The logistics of building offshore will also be more complex and financial implications greater compared to onshore sites. Further work is also required on enabling monitoring, maintenance and research opportunities at offshore structures, for example considering structure design, remote viewing and access.

Conclusion	Context
Kittiwakes have successfully colonized many offshore structures and are probably present on more than are currently documented. Colonization began during the early 1990s and has continued up to the present day.	If the environmental conditions (see **section 5.1**) are favourable, birds readily colonise structures often within a few years of their construction. Birds are still colonising new structures.

Table 1. Offshore structures which have confirmed the presence of breeding kittiwakes.

Location	Installation	Owner	Latitude & Longitude	Distance offshore[1] (km)	Water Depth[1] (m)	Date colonised	AON (most recent count)	source
Netherlands	L8-P (unmanned 1 visit per 12 wks)	Wintershall	53°38'N 04°34'E	75	32.4	2000	45 (2005)	Camphuysen *et al.* (2005), Camphuysen & Leopold (2007), Geelhoed *et al.* (2011)
	L8-A (satellite platforms)	Wintershall	53°35.N 04°28.E	75	26.5	2005	4 (2006)	
	L7-PB (integrated platform)	Total	53°36.N 04°12.E	85	34.7	Not known	4 (2006)	
	K15-FC-1 (unmaned)	Pentacon Alpha	53°15'N 03°45'E	73	25	Not known	16-25 (2010)	
Norway	Draugen	AS OKEA	64°21'N 7°47'E	75	252	Early 90's	674 (2019)	Christensen-Dalsgaard *et al.* 2019
	Heidrun	Equinor Energy AS	65°20'N 7°19'E	165	345	Early 00's	252 (2019)	
	Skarv	Aker BP ASA	65°41'N 7°39'E	170	368	2014	198 (2019)	
	Goliat	Vår Energi AS	71°30'N 22°30'E	60	371	2016	40 (2019)	
	Asgard B	Equinor Energy AS	6°47'E 65°6'N	157	300	Not Known	Not Known	
	Norne?	Equinor Energy AS	8°4'E 66°2'N	153	380	Not Known	Not Known	
	"Ekofisk" exact platform unknown.	ConcoPhillips	56°32' N 3°12' E	263	72	2014	50 (2014)	"Artsobservasjon er" artsobservasjoner . no. the Norwegian platform for

[1] Distance offshore and water depth have been gained from information contained within the attributes of EMODnet offshore activities shapefiles.

Location	Installation	Owner	Latitude & Longitude	Distance offshore[1] (km)	Water Depth[1] (m)	Date colonised	AON (most recent count)	source
								registering observation
UK (Irish Sea)	Morecambe Central gas platform	British Gas	53°50."N 3°34."W	35	32	1998	220 (2016)	JNCC 2020 (SMP)
	Walney OWF	Orsted	3°29'24"W 54°2'36"N	28	20	Unknown	150 (est. 2021)	Photos of breeding birds seen
UK (North Sea)	UKSNS8	Confidential	Confidential	204	40	unknown	440	Orsted vessel based surveys 2021
	UKSNS16	Confidential	Confidential	82	32	unknown	372	Orsted vessel based surveys 2021
	UKSNS11	Confidential	Confidential	141	23	unknown	266	Orsted vessel based surveys 2021
	UKSNS12	Confidential	Confidential	121	22	unknown	260	Orsted vessel based surveys 2021
	UKSNS6	Confidential	Confidential	107	26	unknown	57	Orsted vessel based surveys 2021
	UKSNS15	Confidential	Confidential	93	32	unknown	28	Orsted vessel based surveys 2021
	UKSNS14	Confidential	Confidential	100	21	unknown	26	Orsted vessel based surveys 2021

Location	Installation	Owner	Latitude & Longitude	Distance offshore[1] (km)	Water Depth[1] (m)	Date colonised	AON (most recent count)	source
	UKSNS1	Confidential	Confidential	49	40	unknown	1	Orsted vessel based surveys 2021
	UKSNS28	Confidential	Confidential	30	37	unknown	c.100	Orsted vessel based surveys 2021
	UKSNS39	Confidential	Confidential	76	22	unknown	200?	Orsted Aerial surveys
	UKSNS40	Confidential	Confidential	157	41	unknown	3-4	Orsted correspondence with operators (OSC report 2021)
	UKSNS44	Confidential	Confidential	57	38	unknown	? (400 birds reported)	Orsted correspondence with operators
	UKSNS46	Confidential	Confidential	159	28	unknown	4-16	Orsted Aerial surveys + (OSC report 2021)

Table 2. Offshore structures which have recorded kittiwake presence (but breeding has not been confirmed)

Location	Installation	Company	Latitude & Longitude	Distance offshore km	Bathymetry (m)	Date colonised	Status	comments	source
Netherlands	PE-K4-BE	Wintershall	53°46.15N 03°11.47E	150	45.6	Not known	prospecting adults	40 prospecting 230 Adults associating with platform (summer 2005)	Camphuysen & Leopold (2007)
	L8-H	Wintershall	53°34.09N 04°34.37E	65	26.5	Not known	prospecting adults	No counts available	
	L5-B	Wintershall	53°42.19N 04°36.03E	75	35	Not known	prospecting adults	11 prospecting 15 Adults associating with platform (summer 2005)	
	L5-C	Wintershall	53°41.68N 04°32.57E	75	35	Not known	prospecting adults	23 prospecting 46 Adults associating with platform (summer 2005)	
UK (North Sea)	Barque PB	Shell	53°36'6"N 1°31'36"E	70	22	2010?	present	possible breeding birds observed May 2010	Leopold & van Bemmelen (2010) in Geelhoeld *et al.* (2011)

Location	Installation	Company	Latitude & Longitude	Distance offshore km	Bathymetry (m)	Date colonised	Status	comments	source
	UKSNS02	Confidential	Confidential	75	45	Not known	Birds present not breeding – roosting/ prospecting?	4 birds sat on ledges of structure	Orsted vessel based surveys 2021
	UKSNS03	Confidential	Confidential	74	54	Not known	Birds present not breeding – roosting/ prospecting?	48 birds sat on potential breeding ledges on structure, plus c. 70 birds in vicinity	Orsted vessel based surveys 2021
	UKSNS04	Confidential	Confidential	124	49	Not known	Birds present – no evidence of breeding	c.20 individuals present on structure	Orsted surveys 2021(Aerial and boat)
	UKSNS05	Confidential	Confidential	94	54	Not known	Birds present – no evidence of breeding	c.60 individuals present on structure	Orsted surveys 2021(Aerial and boat)
	UKSNS23	Confidential	Confidential	97	32	Not known	Birds present – no evidence of breeding	Small number of kittiwake present on structure in May	Orsted vessel surveys + (OSC report 2021)
	UKSNS24	Confidential	Confidential	108	26	Not known	Birds present – no evidence of breeding	Small number of kittiwake present on structure in May	Orsted vessel surveys + (OSC report 2021)

Location	Installation	Company	Latitude & Longitude	Distance offshore km	Bathymetry (m)	Date colonised	Status	comments	source
	UKSNS27	Confidential	Confidential	53	50	Not known	Birds present – potentially breeding	10 birds present on ledges, only part of platform visible and too distant to confirm presence of nests.	Orsted vessel based surveys 2021
	UKSNS49	Confidential	Confidential	97	13	Not known	Birds present – no evidence of breeding	Small number of kittiwake present on structure in May	Orsted correspondence with operators (OSC report 2021)

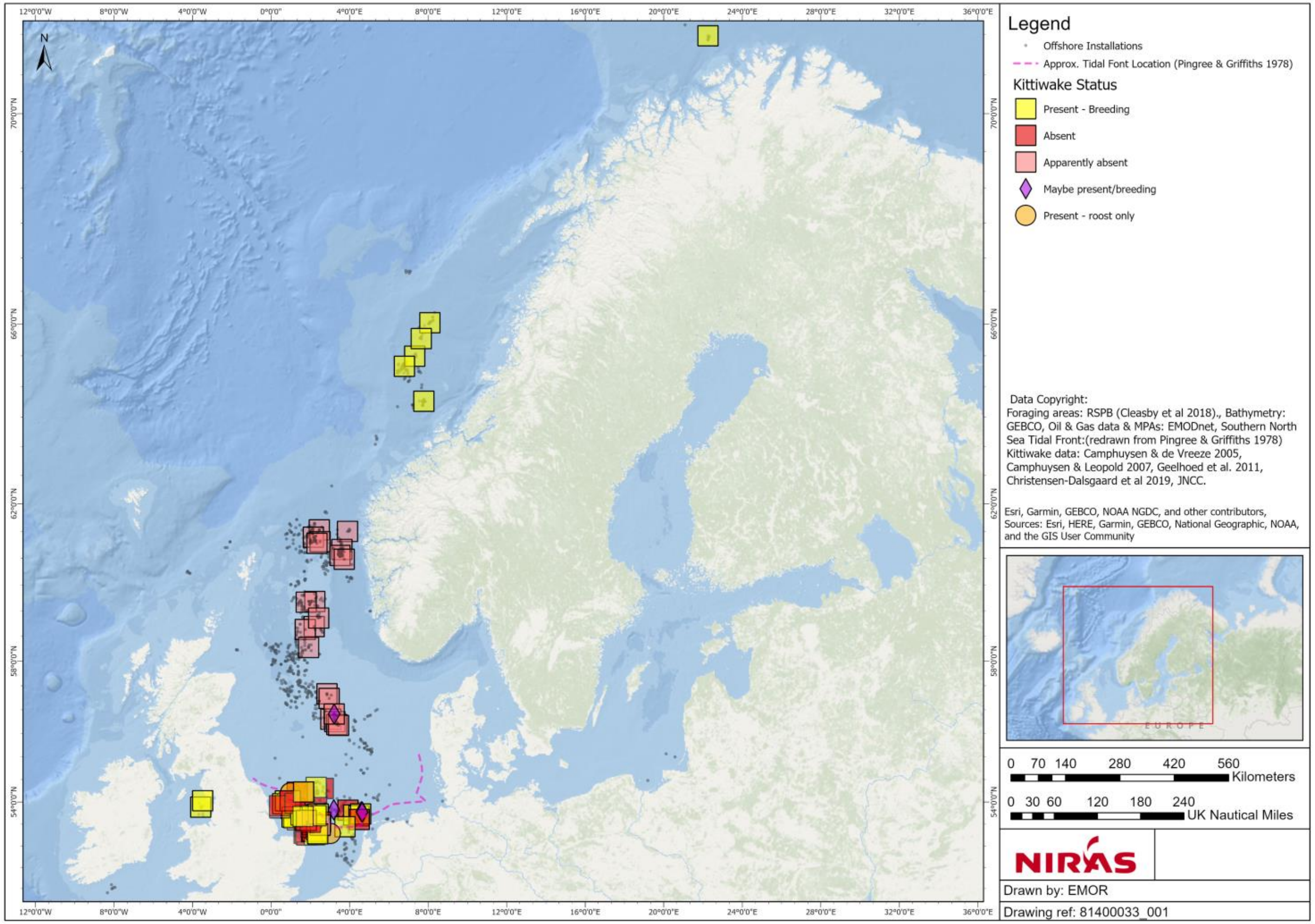

Figure 1. Known and potential locations of breeding kittiwakes on offshore installations (zoomed in maps for each region can be found in Appendix E).

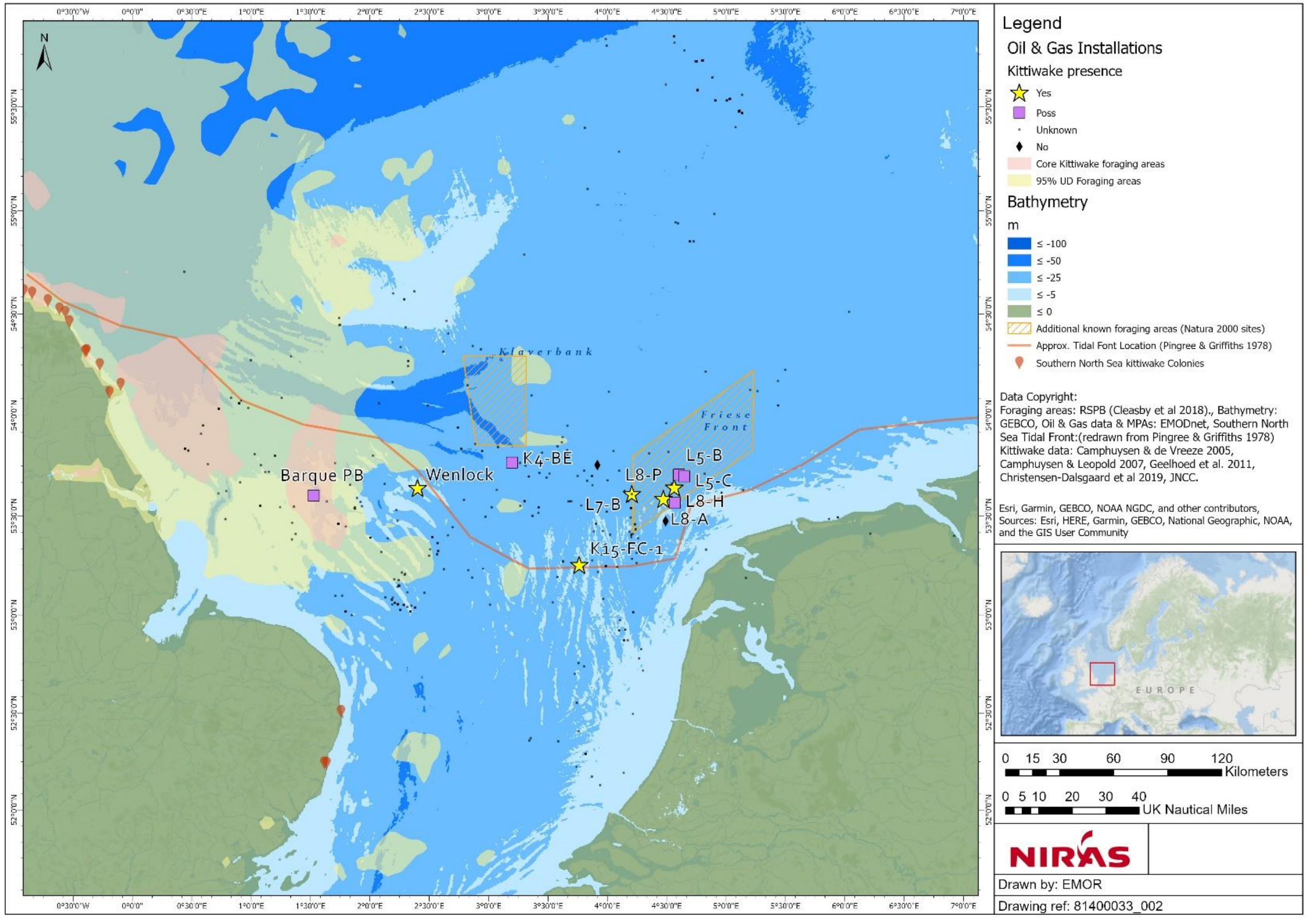

Figure 2. Southern North Sea occupied offshore installations based on published information. Map shows water depths, coastal kittiwake colonies along with the known foraging hotspots for kittiwake in the UK. The approximate location of the tidal mixing front and areas where birds are thought to forage within the eastern North sea are also shown.

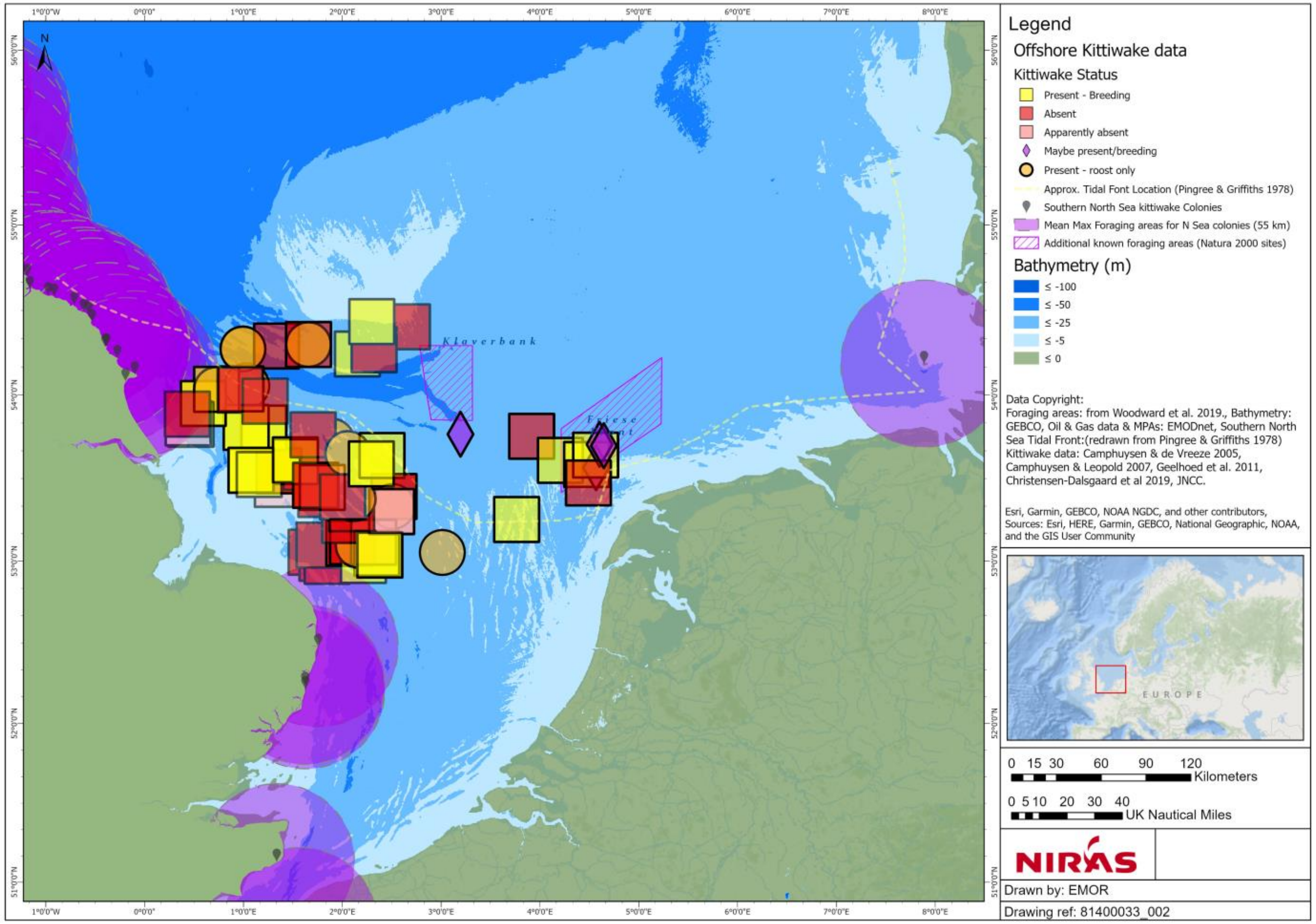

Figure 3. Updated southern North Sea occupied offshore installations including 2021 targeted survey results and information gained from third parties. Map shows water depths, coastal kittiwake colonies along with the mean foraging range of birds from coastal colonies (Woodward *et al.* 2019). The approximate location of the tidal mixing front and areas where birds are thought to forage within the eastern North sea are also shown.

3.2 Kittiwake population and productivity trends at offshore locations

3.2.1.1 As offshore installations are not currently easily accessible to ornithologists, successful recording of new breeding colonies has largely relied on opportunistic sightings from ship surveys, amateur ornithologists working offshore (e.g. North Sea Bird Club) or reports from companies operating the sites. The presence of breeding birds had until 2021, only been confirmed at twelve locations in the Dutch North Sea, Norwegian Sea, Barents Sea and Irish Sea (See **Table 1**, **Figure 1** & **Figure 2**). commissioned surveys of installations of the UK southern North Sea region have confirmed the presence of breeding kittiwake at an additional thirteen locations in the southern North Sea (Orsted 2021, see survey reports at **Appendix A**, **Appendix B**, **Appendix C**). Occurrence of breeding birds is suspected at additional locations in these areas (especially in the southern North Sea) and further work is ongoing to confirm this. Hornsea Project Four is currently reaching out to oil and gas suppliers to gain a better picture of which of these sites are occupied, as has been done in Norway (Christensen-Dalsgaard 2020). For the same reasons mentioned above, there is currently limited data available to assess trends in numbers and productivity at these sites. Hornsea Project Four carried out productivity surveys on six installations where breeding colonies were found in 2021, providing a baseline for future surveys from which trends in breeding success could be assessed.

3.2.1.2 With respect to colonisation rates and population growth rates at colonies, again there is a lack of data. **Figure 4a** shows the data available for the few sites, where multiple counts have been documented across the years (Morecambe Gas Platform and the Dutch platform L8-P). An annual survey has been set up recently at some Norwegian sites (Christensen-Dalsgaard 2020) but historic data are sparse with only rough construction dates and colonisation estimates available (**Figure 4b**).

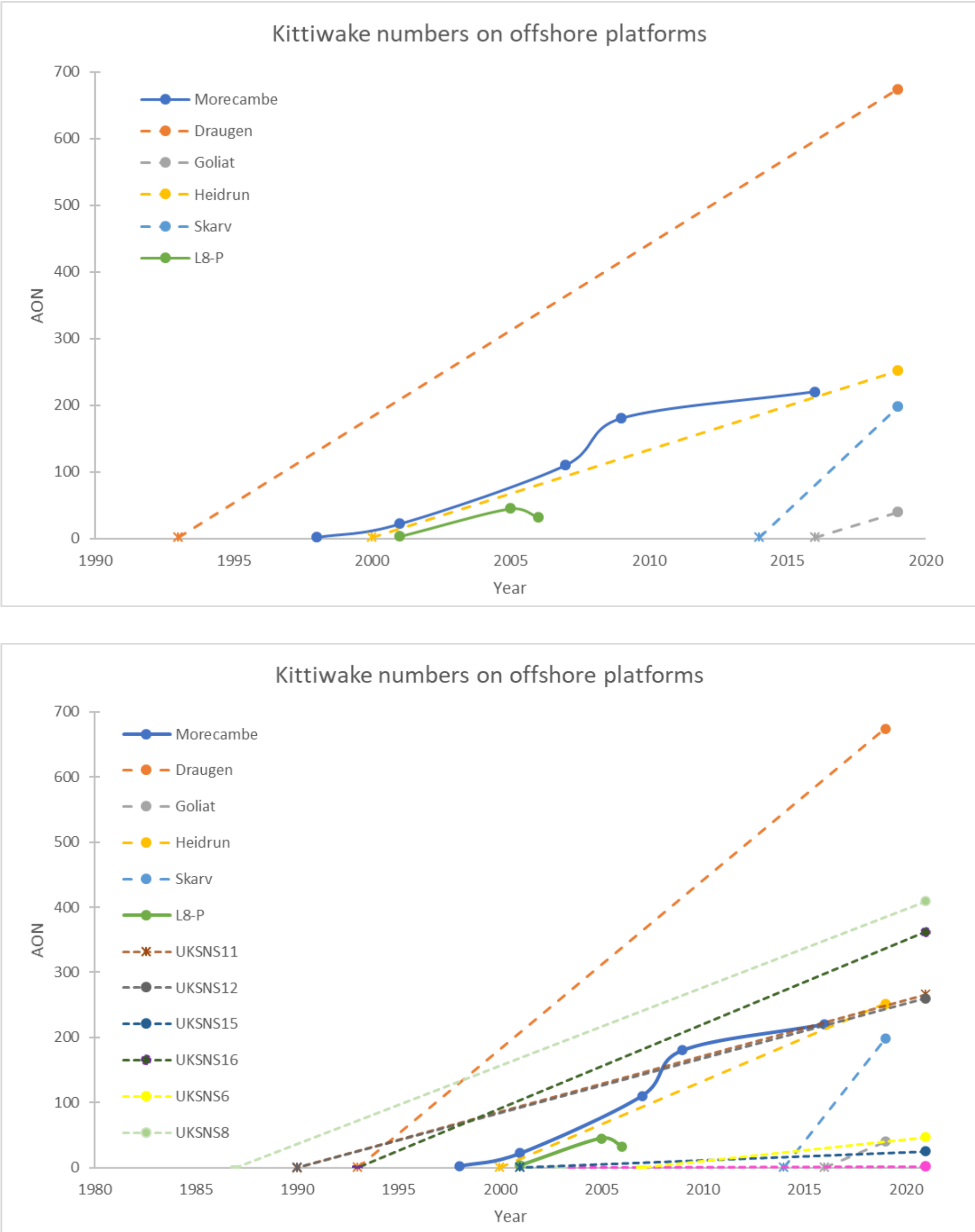

Figure 4. Numbers of kittiwakes known to be breeding at offshore Oil/Gas sites. A.) Top panel-From published data, B.) Bottom panel – Updated with 2021 Survey census results (Note: installations have been anonymised to maintain confidentiality). Actual counts of apparently occupied nests (AON) are shown by filled circles, asterixis represent estimated colonisation dates based on installation construction date. Actual trends are shown by solid lines, estimated trends are shown by dashed lines.

Population trends

3.2.1.3 Colony growth patterns appear to follow those seen at natural sites (**Figure 4**). Here, new colonies are usually created by young birds and will typically grow rapidly, and often double in size annually for the first few (2-4) years. Thereafter the colony increases at a progressively lower rate c. 10%–20% per annum (Coulson 2011, Kidlaw 2005). Initial growth in the first five to ten years or so is almost entirely dependent on successfully attracting immigrants. This is because potentially philopatric individuals have not reached breeding age and the number of young produced in the first few years of the colony is generally lower than established colonies (Coulson 2011). However, colonies which were established in the early 1990's to 2000's were colonised during a period of population expansion of kittiwakes across the UK in general, so comparable rates may be opportunistic as recent UK trends show a decrease in kittiwake numbers breeding onshore (JNCC 2020).

3.2.1.4 In Norway, new installations have been colonized very quickly, for example, the Goliat platform was constructed in 2015 and birds began breeding on the structure within a year or two. The offshore populations tend to grow rapidly in the beginning, but seem to slow as the most popular places become occupied (S. Christensen-Dalsgaard pers. comm.). Morecambe Bay Central Gas Platform has showed a similar rapid initial increase, with a levelling off at around 200 pairs (see **Figure 4**). The last documented count at the platform was in 2016, this published in JNCC's Seabird Monitoring Programme online database. (JNCC SMP 2020). Whilst kittiwakes have been reported as breeding on other offshore oil and gas installations to JNCC, SMP has received no additional records. It's pertinent to note that JNCC's marine ornithologists have concurred with the current study's findings of not being aware of any systematic survey of UK offshore installations for breeding seabirds (S. O'Brien et al. pers. comm.). Elsewhere, colonies in the Dutch North Sea were visited and counted by researchers during the early phase of colonisation (Camphuysen et al. 2005, Camphuysen & Leopold 2007). No further counts/studies have taken place at these colonies, but it is thought that birds have begun breeding on more platforms surrounding L8-P (K. Camphuysen pers. comm.). Around 150 pairs were reported to be breeding on one of the substations at Walney offshore wind farm in 2021 . Colonisation is thought have occurred in the last three or four years from when numbers have increased year on year (Simon Stanway, pers. comm. 2021).

3.2.1.5 When considering population trends of kittiwake nesting on offshore oil and gas installations, account needs to be made of temporary or permanent measures taken at some sites to deter breeding birds. For example at the Heidrun platform, if the operators are required to undertake works that may result in disturbance to nesting birds, it is understood that netting is installed pre-breeding to discourage the birds from returning ahead of the works (S. Christensen-Dalsgaard pers. comm.). Such operations are likely to reduce the colony's size and overall productivity (as discussed later) in the year that netting excludes birds from nesting ledges on part of the platform.

3.2.1.6 Though not fully offshore (c.100-400 m off Suffolk coast), there is a colony of kittiwakes breeding on Sizewell Rigs; on old outflow structures from the nuclear power station. These structures are similar to those on offshore platforms, with birds nesting on the narrow metal ledges beneath the platform (see **Appendix A**). Birds were first recorded breeding at the site in 1995 with 22 apparently occupied nests (AON; Suffolk Bird Report 1996). Numbers increased rapidly to around 200 pairs in 2001. Since then numbers have remained stable on the colony between 200-250 pairs. A full census, with observers landing on the platforms, was carried out in 2008 and counted 502 AON. However, in the same year, Suffolk Bird Club recorded 374 nests which were presumably seen from shore, suggesting their previous counts represent minimum estimates of birds. Akin to birds nesting on offshore platforms, the Sizewell population is space-limited and nests on the platform are unlikely to exceed 500 pairs (McMurdo-Hamilton 2016). Camphuysen et al. (2005) also states the prospects for the Dutch platform LP-8 seem promising, except for a limitation of nest sites.

Productivity

3.2.1.7 Productivity rates are likely to be relatively low during the early stages of colony establishment. The reasons for this are twofold. Firstly new colonies are likely to be established by young inexperienced birds i.e. first time breeders, which generally have lower productivity than experienced birds (Horswill and Robinson 2015). Secondly, at low densities, kittiwake nests are more vulnerable to predation (Coulson 2011).

3.2.1.8 During the first few years that birds tried to breed on the Morecambe Bay Gas Platform, it was noted that attempts had been "foiled by scavenging herring gulls taking the eggs. The two pairs on the Irish Sea platform overcame that problem by choosing a site inaccessible to the marauders" (Unwin 1999).

3.2.1.9 Camphuysen & Vreeze (2005) studied birds breeding at the first offshore colony to establish in the Dutch North Sea (L8-P). They found mean egg size and clutch size was lower than those found at coastal breeding sites. It was thought that this was likely to be due to a newly established colony at the time the measurements were taken.

3.2.1.10 Once a colony is established there are potential benefits associated with offshore nesting sites that are likely to increase productivity and survival rates. Birds are likely to be much closer to foraging areas, and therefore should have shorter foraging trips which are generally linked to higher breeding success e.g. Daunt et al. 2002, Lewis et al. (2001). The colony may also experience lower predation pressure as they are further from land where many terrestrial and aerial predators are unlikely to travel from across the sea.

3.2.1.11 In Norway, kittiwakes breeding on Oil/Gas platforms do appear to have higher productivity than those colonies in the same years situated on the coast, both at natural breeding sites, and in most cases (but not all), on man-made structures (Christensen-Dalsgaard et al. 2019). Those birds breeding offshore had a moderate to high productivity, ranging on average between 0.61–1.07 chicks per nest. Christensen-Dalsgaard et al. (2019) also found kittiwakes breeding on more exposed parts of the platforms experienced higher predation rates from large gulls, and had a lower productivity, than birds breeding on more sheltered parts of the platforms.

3.2.1.12 Productivity of colonies nesting on offshore rigs in the southern North Sea showed the same pattern described by Christensen-Dalsgaard et al. (2019) for Norway; most colonies (5 out of 6) had higher productivity than the onshore UK national average and regional average from British east coast colonies (values of 0.69 and 0.82, respectively, Horswill and Robinson 1995). Results from these Orsted commissioned surveys also suggest that nests in more sheltered locations within a platform are slightly more productive than exposed sites, and fewer nests failed at more sheltered locations (see Orsted Survey report from second boat based survey at **Appendix B**). The only colony surveyed which had relatively poor productivity (compared to the UK national average and other offshore installations) was a small colony on a rig which had been partially decommissioned two years prior, the only nesting ledges available were on the leg struts, so are likely to be more exposed than other sites.

3.2.1.13 Colony success and growth rates will also depend on the availability of recruits, food resources and survival rates. The size of the pool of recruits available in the North Sea is unknown and is difficult to ascertain, this has been identified as a knowledge gap (Black & Ruffino 2020).

3.2.2 Trends in nearby natural colonies

3.2.2.1 The global kittiwake population has decreased by 40% since 1975 (Descamps et al. 2017; BirdLife International 2018). At Heligoland, in the south-eastern North Sea, numbers of breeding kittiwakes began to decline in 2004, after being relatively stable for many years (Markones et al. 2009; Dierschke et al. 2011). In Norway natural kittiwake colonies are also in decline (Sandvik et al. 2014). Populations at the few existing Danish colonies increased up to the mid-1990s and are now thought to be stable (Lerche-Jørgensen et al. 2012, M. Frederiksen pers. comm.). In the UK the population is also declining, with largest declines recorded at colonies in the north and north-west. Along the east coast of the UK, the average rate of decline is much slower (2.6% p.a.). In the west of the UK, the average rate of decline is also lower at 7.5% p.a. (JNCC 2016).

Conclusion	Context
Monitoring populations in the offshore environment is challenging and there are likely to be more occupied sites than are publicly documented.	Continuation of work to build a database of the whole offshore kittiwake population in the North Sea would be beneficial to better understand this issue.
Offshore populations appear to be increasing, but may be restricted by availability of appropriate nesting spaces at some sites.	Colony size and productivity rates at many offshore sites could increase if suitable additional nesting spaces are provided.
Productivity rates may be better than those at many coastal sites.	Offshore sites may provide a vital refuge to buffer against declining coastal populations

3.3 Nest site characteristics of offshore breeding birds, including proximity to known foraging sites and nesting material used

3.3.1 Factors influencing the geographic location of offshore colonies

Prey availability and hydrographic features

3.3.1.1 Kittiwake distribution at sea during the breeding season is largely driven by factors which influence prey availability (Cox et al. 2013) within the constraints of foraging range from colony for breeding adults. Preferred prey tends to be small fish, with sandeel being particularly important in the northern North Sea. However, sprats, clupeids and juvenile whiting may also make up important components of birds' diet elsewhere in their range (Chivers et al. 2012, Bull et al. 2004, Furness and Tasker 2000, Markones et al. 2009). Kittiwakes can only access prey in the top metre of the water column, so they are often associated with features like tidal fronts which concentrate prey near the water surface. Hydrographic fronts e.g. shelf breaks and tidal mixing fronts are known to be important foraging areas for the species (Leopold 1993, Skov and Durinck 1998, Markones 2007). Kittiwake colonies in the North Sea are all located in relatively clear water, north of the Frisian Front (e.g. see **Figure 2**), the dividing line between muddy, cloudy water from Southern Bight and the relatively clear water of the central North Sea (Geeholed et al. 2011). However, within the relatively clear water areas, it's the areas of weaker stratification of waters that are associated with increased breeding success in kittiwake (Carroll et al. 2015). Birds do not appear to forage over deeper heavily stratified waters (Scott et al. 2010).

3.3.1.2 Birds have been recorded breeding on offshore platforms in the Norwegian Sea and Barents Sea but appear to be absent from platforms in the northern North Sea (Christensen-Dalsgaard 2019). However, there is one breeding record from a Norwegian platform in the mid North Sea which was found on a Norwegian nature recording database (Christensen-Dalsgaard pers. comm.). Birds have been recorded breeding on platforms in the southern North Sea off the Dutch coast and are likely to be found on more platforms in this region, especially along the frontal regions (see **Figure 2**) (K. Camphuysen pers. comm). Anecdotal reports of birds seen prospecting around platforms and unconfirmed breeding reports seem to fit this pattern (Leopold & van Bemmelen (2010), in Geelhoeld (2011); **Table A 2**). North of this front, breeding kittiwakes are less likely to occupy offshore installations. although there is virtually no information on the presence or absence of breeding birds on platforms in this area to confirm or disprove this theory. Distribution of birds during the summer months from at sea survey data (e.g. ESAS/SEAPOP) largely support this trend. Breeding birds have also been recorded on offshore platforms in the Irish Sea off the coast of Morecambe Bay.

Oceanographic features

3.3.1.3 Platforms which have been colonised are located between 35 -170 km offshore, with the Norwegian colonies located further offshore than those in the southern North Sea. Water depths surrounding occupied Norwegian platforms (range 252 m – 371 m) are deeper than those in UK/Dutch waters (range 25 m – 35 m). et al.

3.3.1.4 The influence of the physical features of waters surrounding colonies in respect to foraging preference, is identified as a critical determinant in the location of kittiwake colonies (K. Camphuysen pers. comm.). Areas where the water column is well-stratified with the movement of tidal currents over uneven topography is thought to be important in creating surface aggregations of sandeels which kittiwakes exploit (Embling et al. 2012). Much of the Southern Bight is considered unsuitable as foraging area as it has mixed, turbid waters, with kittiwake having a preference for clear more saline waters such as those found off much of E. Scotland and England, north of The Wash, and then Heligoland in Germany (and further north in Denmark). The Netherlands lack suitable cliffs for natural nesting sites and the ideal hydrographic conditions only occur further offshore, north of the Frisian Front area, which is where the Dutch platforms have been colonized, and where further colonisation in the future is predicted, where anthropogenic activities allow (K. Camphuysen pers. comm.).

Proximity of colonies to foraging areas

3.3.1.5 On average, kittiwakes forage within 54.7(±50.4) km of their breeding colony but can travel up to 156.1(±144.5) km to find food, their mean maximum foraging range (Woodward et al. 2019). However, shorter foraging distances are generally linked to higher breeding success (e.g. Daunt et al. 2002, Lewis et al. 2001). An offshore breeding site may enable birds to breed closer to foraging sites, reducing energetic costs associated with finding food, which is likely to result in increased productivity.

3.3.1.6 In the UK, tracking data is available from many seabird colonies, which with predictive modelling techniques has been used to map the key foraging areas for kittiwakes in UK waters (e.g. Cleasby et al. 2018) (see Map 2). These distributions have been informed by tracking data and distance from known kittiwake colonies, consequently outputs/results are defined by this. If additional data had been available to add to these models, specifically tracking data from other North Sea colonies to the south of FFC SPA and the presence of undocumented colonies at offshore locations, key foraging areas may be seen to extend further into the southern North Sea. This would most likely be to the east, along the frontal regions where many offshore platforms are located.

3.3.1.7 Existing data for the UK southern North Sea region show most kittiwake breeding colonies to occur offshore in the area south of the Flamborough front (as depicted by Pingree and Griffiths 1978). Those offshore colonies are also largely beyond mean max foraging range (55 km) of FFC SPA birds to the north and those birds breeding at Lowestoft to the south (**Figure 3**). This area is also known to support foraging kittiwake from FFC SPA (Cleasby et al. 2019), which is indicative of favourable prey availability in the area.

3.3.1.8 Kittiwakes can display high foraging site fidelity (Irons 1998, Harris et al. 2020). Kittiwake distributions may be modulated by density dependent competition between individuals nesting at other colonies nearby (e.g. Wakefield et al. 2013). Recent tracking studies show birds tend to avoid foraging in areas that are populated with a higher number of birds from a neighbouring colony than from their own colony (Wakefield et al. 2017). There is also some evidence to suggest that these patterns may also operate on smaller scales i.e. at a sub colony level (e.g. within RSPB FAME tracking data). This may be an important factor to consider when choosing an area in which to enhance kittiwake populations, as increased competition for the same food resources could potentially impact the breeding success (and therefore population numbers) of birds in both the 'new' or established colonies.

Though inter-colony overlap in foraging areas does occur, especially in highly productive areas, it is often remote from all colonies (Bolton et al. 2018). Density dependent processes appear secondary to food availability with no negative relationship between colony size and breeding success found in kittiwakes (Frederiksen et al. 2005). Existing offshore populations seem to be coexisting with the FFC SPA population and have comparable breeding success to coastal nesting birds, however there is a lack of knowledge surrounding where these birds are foraging and if these areas are shared with onshore nesting birds.

3.3.1.9 In Dutch waters, the Frisian Front and around the steep slopes of the Botney Gat in the Klaverbank offers rich and predictable supply and therefore prime locations for breeding kittiwake to colonise platforms (Camphuysen & Leopold 2007). Surveys of the Dutch North Sea report opportunistic foraging around platforms and note that foraging kittiwakes were seen between platform L8-P and the shipping route, but no further south of it (Camphuysen & Vreeze 2005, Geelhoeld 2011).

3.3.1.10 Birds from the Heligoland colony forage along fronts within the German Bight, during the summer with birds show strong associations with ephemeral fronts (Markones 2007).

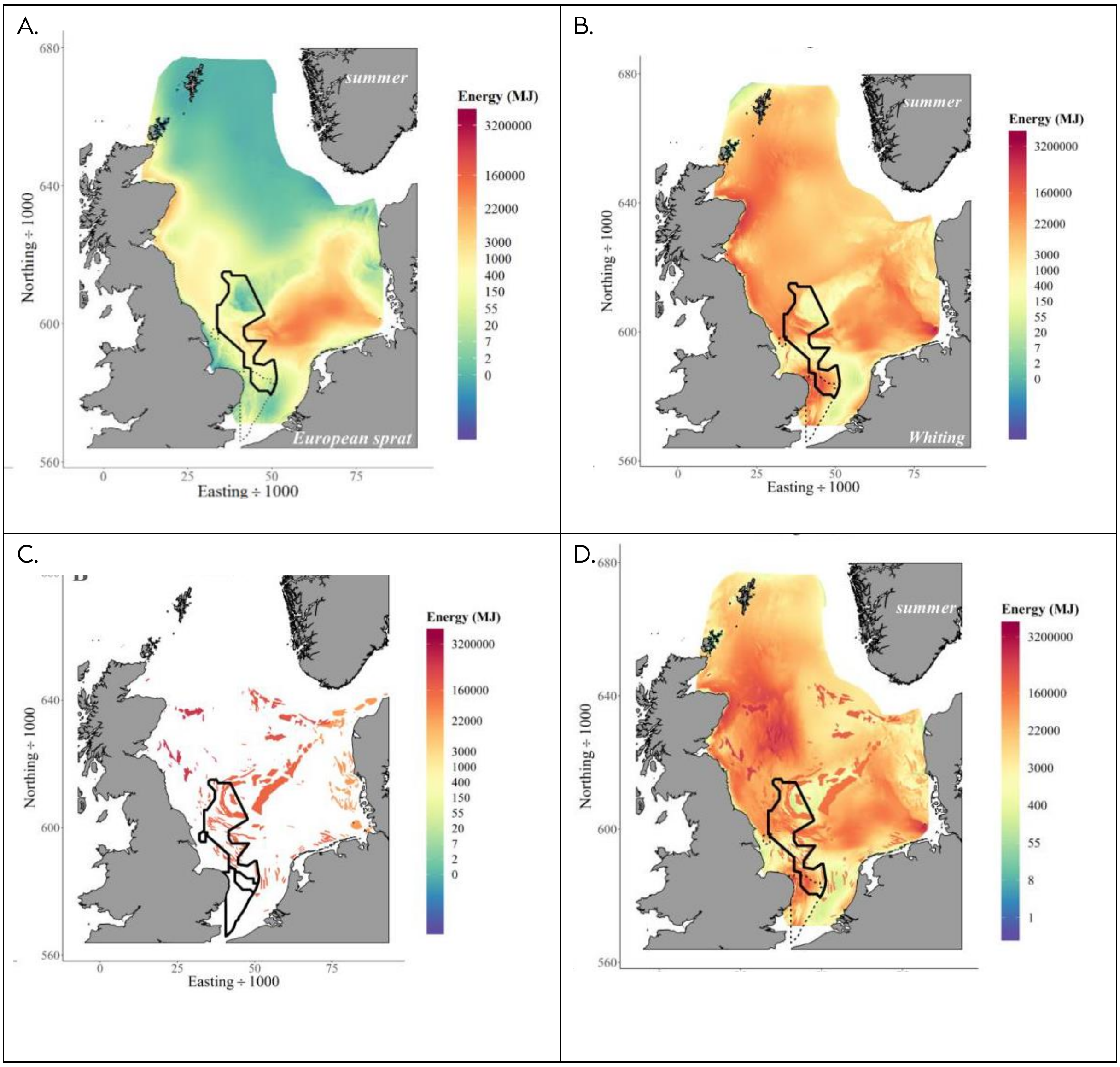

Figure 5. Figures from Ransijn *et al.* (2019) showing potential key prey hotspots (calorific content of prey) for harbour porpoise for species which are also be important to kittiwake diet. A. Sprat, B. whiting, C. Sandeel, D. Total for all prey species in summer (April-September). All data from 2016.

3.3.1.11 In Norway, breeding birds forage in coastal waters and in a productive coastal front along the Norwegian shelf break. These frontal areas at the shelf break are situated more than 300 km from the coast of Southern Norway, whereas off the coast of northern Norway, near Lofoten and Vesterålen, the shelf is narrow with the edge approaching the coast to within 10 km (Christensen-Dalsgaard 2011). Further north, key foraging areas include inter-tidal glacier fronts (Urbanski et al. 2017).

3.3.1.12 Feeding conditions in the southern North Sea are currently thought to be favourable. Recent work by Ransijn et al. (2019) mapped key prey hotspots for harbour porpoise. Although harbour porpoise forages in a very different way to kittiwake and there is only a weak association between kittiwake and harbour porpoise foraging habitat (Scott et al. 2010), they do share many of the same key prey species i.e. sandeel, whiting and sprats. Many of the key areas of abundance of the prey species of the Harbour Porpoise, in terms of calorific content, overlap with the locations of offshore platforms occupied by kittiwake in the southern North Sea, so may also provide a proxy for describing where additional key foraging areas for kittiwake are located e.g. compare **Figure 5** and **Figure 2**. Kittiwakes do appear to share the same foraging habitat as minke whales (Scott et al. 2010), therefore, information on minke whale distribution could also be used as a proxy to identify suitable areas further offshore for kittiwake. Kittiwakes are also thought to rely on prey facilitation by auks and on habitat characteristics that are predictable, but sparse and patchy (Camphuysen et al. 2006).

Data gaps - where birds don't occur.

3.3.1.13 Christensen-Dalsgaard et al. (2019) gathered information for their study by sending out questionnaires to Oil and Gas companies. with platforms located in the Norwegian regions of the North Sea. The absence of a response was taken to indicate breeding kittiwakes were unlikely to be present. Based on this assumption, the populations nesting offshore in the North Sea were found to represent an additional 1.3% of the Norwegian population (Christensen-Dalsgaard 2019). However, this may be considered an underestimate as Oil and Gas operators may be reluctant to publicise the presence of birds nesting on platforms when considering responding to such questionnaire surveys. This is because acknowledging through a questionnaire survey of the presence on a platform of breeding birds, may lead the site operator to additional restrictions and expense especially when it comes to decommissioning platforms. Prior to work carried out as part of the Hornsea Four project, to our knowledge, no information has been collected on kittiwake breeding presence/absence for the rest of the North Sea. This represents a considerable gap in knowledge regarding kittiwake distribution and size of the population of birds breeding offshore in the North Sea.

3.3.1.14 Hornsea Four are taking steps to address this gap in the southern North Sea, however, arranging access to cover a high number of platforms within a short survey period (either using boat or aerial based surveys) has proved challenging as there are multiple licencing and health & safety regulations which must be agreed and adhered to, and these can vary somewhat between operators. Therefore sample size and coverage of platforms has been limited. Permissions and permits are required in order to survey within 500 m (i.e. within exclusion zones) of installations. During boat based surveys, activities had to be agreed with each O&G operator and installation separately, and had to be scheduled around O&G

operations, meaning some platforms could not be surveyed during the vessel survey dates. Following these procedures and completing the necessary documentation in the field prior to entering the exclusion zones increases the time required to survey each installation. To date information has been gained from 50 installations in the southern North Sea, 26% of these had populations of breeding kittiwake, however, this figure is likely to be an over representation of actual occupation rates as surveys initially targeted installations which were thought to have breeding birds present. The number of offshore platforms in the UK waters as of October 2017, is reported as 296, with 158 in the southern North Sea (Oil and Gas Authority Open Data Portal, 2021). Therefore, surveys to date represent a coverage of around 32%.

3.3.2 Comparisons of occupied vs unoccupied installations

3.3.2.1 A number of installations where birds were absent have been documented, and photographs taken during Orsted surveys in 2021. A subjective comparison was made between occupied sites and unoccupied installations (See first boat based survey report at **Appendix A**); Some unoccupied sites were known to be actively using bird deterrents, and nest site availability (presence of suitable ledges) seemed to be limited at some other installations. Human presence or the regularity of manned operations on a rig may influence the establishment of breeding colonies on a site (see survey report **Appendix C**), however there are examples of birds co-existing on manned installations e.g. Morecambe gas platforms. A number of installations appear to offer suitable ledges with no known deterrents but were unoccupied by kittiwakes. Understanding the factors driving kittiwake distribution and occupancy is likely to involve a complex mix of biological and anthropogenic factors, many of which could be difficult to establish and measure empirically. Factors such as: density dependant competition (distance to existing onshore colonies e.g. FFC SPA, or potential overlap with known foraging areas of these birds); number of rigs present in an area (nest site availability); distance to the nearest occupied installation and colony size (having a pool of birds which may attract in new recruits or conversely draw recruits away from other potentially suitable but unoccupied sites); proxies associated with prey availability like water depth, distance from front or other oceanographic features; and the age of installations and frequency of operational activities, or other factors which may deter birds from nesting at a site (either historically or current, whether intentional or not), could all play a role. Further work including the collection of additional data and statistical modelling would be needed to investigate this robustly.

3.3.2.2 Occupancy information from more installations is required to reduce the occurrence of confounding factors in determining the reasons why kittiwakes are choosing to breed on some installations and not others, for example, some installations which were found to be unoccupied during boat-based surveys but seemed structurally suitable were in locations close to the foraging areas used by FFC SPA birds, but also had active human presence on the site during the survey. Timescales over which data can be collected are limited due to project time constraints, ideally multiple years data would be more robust, however, very little information on offshore nesting had been established in this region prior to undertaking these surveys. Future work should aim to increase survey effort across the wider North Sea region, could broaden our knowledge but is beyond the scope and timescales of this project.

Conclusion	Context
Prey availability appears to be the most important factor driving colonization distributions. The southern North Sea Frontal regions appear to be favoured.	Areas along the southern North Sea where birds are already colonising installations is likely to be a good area to site a new purpose built structure.

3.3.3 Nest site features (structural)

3.3.3.1 Ledges on offshore rigs fulfil many of the natural nesting requirements for the species and may provide additional benefits e.g. fewer predators and are closer to food sources (Christensen-Dalsgaard 2019).

3.3.3.2 A detailed review of onshore nest site characteristics and parameters can be found in the kittiwake compensation case produced for Hornsea Project Three (NIRAS 2020). A summary of these key features which are equally applicable to an offshore environment include:

- High and steep sided structure, narrow horizontal ledge for nests, small overhang above nest;
- Inaccessible to predators, which offshore would primarily be large gulls;
- Located over water, with ledges facing out towards the sea
- Some shelter from high winds and other adverse weather conditions; and
- Presence of other breeding kittiwakes nearby (this would initially be achieved by providing decoys and playback of kittiwake calls to encourage colonization of a structure).

3.3.3.3 At offshore sites, birds appear to choose narrow ledges (c. 14-25 cm) under helidecks and walkways, mainly on unmanned installations. Unmanned installations are typically accessed infrequently, so are likely to have lower disturbance from human activity and provide some protection from predation by large gulls as the helideck forms a ceiling. However, birds also breed on manned installations e.g. Norway and Morecambe Bay, and seem to habituate to regular human activities/presence (Christensen-Dalsgaard et al. 2019). **Table 3** details features of sites where birds have nested on offshore installations. **Appendix D** contains photographs of the varied locations where birds have found suitable ledges to nest on at offshore locations. Birds have been recorded on both floating (e.g. floating production storage and offloading units) and fixed offshore structures. Further details of fine-scale site selection preferences of birds nesting offshore in the Southern North Sea can be found in the boat based survey reports at **Appendix A** and **Appendix B**.

Table 3. Where birds nest on existing offshore structures. Images of nesting locations at some of these sites can be found in Appendix D.

Jurisdiction	Installation & location	Source
Netherlands	*L8-P* – Under helicopter deck (about 17 m above the sea)	Camphuysen & Vreeze (2005)
	L8-P - East side of the of the two the full deck ('cellar deck') seen from the sea, (10 m above the sea)	
	K15-FC-1 - On H-beams some in the 'interior' of the platform	Geelhoed (2011)
Norway	*Skarv and Goliat* - Suitable ledges on the sides of the platforms	Christensen-Dalsgaard *et al.* (2019)
	Heidrun and Draugen - On ledges on the main construction and the top of the shafts	
UK	*Morecambe Central Gas Platform* – First colonised a ledge behind lots of piping and under another ledge. Now appear to nest all along ledges under walkways and on unmanned satellite platforms (15 to 30 m above the sea).	Unwin (1999). JNCC (2020) (Craig Hannah photos)
	Southern North Sea platforms – on iron I beams under structures and helidecks and along the sides of structures. Most nests appear to be facing outwards (not on ledges facing the centre of platform) and in areas which directly overhang water.	CONFIDENTIAL via Orsted

Ledge size and position

3.3.3.4 On installations in the southern North Sea nesting birds appear to be more prevalent on the east and south-east sides of installations. Camphuysen & Vreeze (2005) found 62.2% of the 45 nests recorded on L8-P offered views to the east or south-east and nests on the south-west side of the platform were empty. As these visits were made during the early stages of colonisation, they are likely to represent the most favourable nesting sites, though the effects of annual variability in storm pattens cannot be discounted. Prevailing winds in this region are west to south westerlies (Šušelj et al. 2010) indicating birds may prefer/ be more successful at more sheltered sites e.g. Camphuysen & Vreeze (2005). At the Heidrun installation in Norway, birds primarily nest only on two sides of the structure, which are thought to be more sheltered from the winds (Christensen-Dalsgaard pers. comm.). At coastal sites, birds also avoid nesting on southern facing slopes in areas where they may be prone to overheating (Coulson 2011). It is thought that artificial nest sites on a French harbour were not colonised due to sun exposure on the southerly facing ledges (J.M.

Sauvage pers. comm.). Birds nesting on installations in UK waters also showed a strong preference for nesting on the Eastern sides of structures (first boat based survey report **Appendix A**).

3.3.3.5 Camphuysen & Vreeze (2005) measured features of kittiwake nest site on L8-P and found birds nesting under the helicopter deck, used ledges which were 14.5 cm wide, and on the cellar deck, birds used ledges between ± 15-25 cm wide. Narrower edges along beams on the main deck and mezzanine deck were not used (Camphuysen & Vreeze 2005). These values fit with those previously recorded at natural sites, where nests are generally located on ledges 20 cm wide (Kidlaw 1999, Olsthoorn & Nelson 1990). Ledges at natural sites also have a near vertical back wall with average slopes of 82.4° (±14.7)(Kidlaw 1999). No measurements were made as part of Orsted's commissioned boat-based and digital aerial surveys, but assessments from digital photographs are indicative of similar ledge sizes to the Dutch platforms, with few nests on narrower ledges.

3.3.3.6 To inform future design principals, shelter from prevailing winds and sites overhanging water are likely important design features, with I-beams providing good nesting sites. The more successful nests in terms of nest success and productivity appear to be those in more sheltered locations, or with microscale features such side partitions that provide additional shelter. Incorporating design features which are likely to improve breeding success, would enhance the chance of the artificial nest structure contributing to additionality. In terms of monitoring, creating a structure that meets these criteria but could be easily viewed would also be advantageous.

Nesting material

3.3.3.7 Kittiwake build nests of mud-based foundation to which further grasses and seaweed are added on top, these are usually collected from the tideline, cliff edges and sea surface typically within 2 km of the colony (Coulson 2011). The availability of mud was thought to be important as it helps to glue the nest to the ledge and appeared to influence the timing of nest building activity (Cullen 1957). It has not been established whether a lack of mud for nest building is an issue for birds nesting offshore or if this could potentially impact breeding success i.e. nests may be more prone to being swept off ledges.

3.3.3.8 Nests on offshore installations may be constructed more simply than at coastal nesting sites with nesting material mainly consisting of seaweed and pieces of plastic debris (Christensen-Dalsgaard et al. 2019). On Dutch Gas platforms, a detailed study of nesting material found nests were built with a mixture of natural materials (primarily seaweeds such as Fucus vesiculosus, Euteromorpha spp., Flustra foliacea, and Ascophyllum nodosum) and all kinds of plastics and nylon (Camphuysen & Vreeze 2005). The authors report nest materials were firmly adhered to the steel construction and even seemingly loose seaweed was well glued (presumably with faecal matter). However, on Norwegian platforms, it is reported that nests seem much simpler than those on natural sites and may not be as well attached to the surfaces. This may make the nests more prone to being dislodged in adverse weather especially early in the breeding season (Christensen-Dalsgaard pers. comm.). However, substantial numbers of birds are nesting offshore and are as productive as coastal nesting birds (if not more so), therefore, this issue is not thought to be detrimental to the establishment of new and successful breeding colonies.

3.3.3.9 Materials identified in offshore nests have been of marine and terrestrial origin (Camphuysen & Vreeze 2005, Christensen-Dalsgaard et al. 2019). However, as kittiwakes collect nesting material that is floating on the sea surface, it is likely terrestrial items may come from debris on the sea surface. Plastic incorporation into seabird nests appears to be a widespread issue, especially in species like northern gannet and European shag (O'Hanlon et al. 2019). However, increased mortality from entanglement with plastic in the nest hasn't been identified as an issue of concern for kittiwake.

3.3.3.10 During Orsted vessel surveys it was noted that nests offshore looked to be less substantial than nests found at onshore colonies, though in some areas on offshore installations large nests indicative of many years' worth of nesting material build up were observed. Again nesting material appeared to be of marine origin and birds were seen collecting floating nesting material from the water's surface close to the rigs. Birds were also observed stealing nesting material from one another in the June surveys. It has been suggested that the availability of mud and nesting material may be a limiting factor to offshore nesting birds, though birds seem capable of constructing nests and raising young successfully on offshore rigs. However, the provision of additional material or mud close to a prospective new colony could aid in encouraging birds to attempt to breed or making nests or increasing stability of nests.

Conclusion	Context
Sheltered ledges between 15-20 cm appear to be preferred at offshore sites. Acquisition of nesting material does not appear to be an issue, though the stability of nests and the impact of this is unknown.	Weather conditions (wind and temperature/sun) should be carefully considered within the design of the structure once the location has been confirmed. Key location and design features for offshore nesting sites are summarised in section 8 (**Table 4**).

3.4 Diet of kittiwakes breeding on offshore installations

3.4.1.1 Camphuysen & Vreeze (2005) used guano and faecal samples to assess diet composition of birds nesting on the L8-P platform in the Dutch North Sea. To date, this is the only study which has examined diets of birds nesting on offshore platforms (some data is being collected at Norweigan sites but has yet to be analysed). The study extracted otoliths (fish ear bones) and hard prey remains to determine the species and size of prey taken. Diet appears to be similar to birds nesting onshore in the northern North Sea regions (Bull et al. 2004, Furness and Tasker 2000). The majority of prey remains were small fish between 5-15 cm length. Sandeel Ammodytes spp made up 84% of birds' diet with the remainder made up of Sprat Sprattus sprattus. A few other remains were found in kittiwake diet samples which included, urohyal (a characteristic bone) of a flatfish, and bones from a herring like Clupeidae. But note, this study was limited to 5 samples from one visit in June, and the methods used have limitations (Johnstone et al. 1990). General conclusions probably cannot be drawn from these results as they may not be representative of the wider population with future research required to assess the diets of birds breeding offshore. In addition, the availability of key prey species in seabird diets has changed dramatically over the past three decades in the northern North Sea (Howells et al. 2018), though changes in conditions in the southern North Sea may be less pronounced.

3.4.1.2 At Heligoland, an island over 43 km offshore in the German Bight (south-eastern North Sea), kittiwake diet differs from the rest of the North Sea population in that is apparently not as reliant on sandeel (Markones et al 2009). Whiting seem to be of particular importance to birds here. In summer, the German Bight represents one of the concentration areas of juvenile whiting within the North Sea[2] and dense schools of juvenile whiting have been recorded in the upper water column of the sea area around Helgoland (Markones et al 2009). In contrast to the northern North Sea regions, the breeding numbers of kittiwakes at Helgoland have not experienced severe declines since 1990, up to 2007, numbers continued to increase before stabilising around 2004 (Markones et al 2009). Though recent data indicate this colony may also now be in decline (see figure 2 in Busch and Garthe 2017).

3.4.1.3 Colonies elsewhere are not necessarily wholly dependent on sandeels either, clupeids (e.g. herring, sprat), gadids (e.g. cod, pollock) and planktonic crustacea can also be important (e.g. Lewis et al. 2001, Chivers et al. 2012).

Conclusion	Context
Diet is likely to be similar to coastal nesting birds within the same region, but few detailed studies exist on the topic.	Birds will take what prey is available at the surface. Birds within the southern North Sea may be less reliant on sandeel, so foraging conditions may be more favourable here than elsewhere.

3.5 Human related issues associated with kittiwake nesting on offshore installations

3.5.1 Bird-human interactions

3.5.1.1 In terms of bird-human interactions, the main concern with kittiwakes nesting on existing installations are related to human health and safety. These concerns are firstly summarised below followed by the impact birds may have on the progress of planned works.

3.5.1.2 Human health and safety issues

3.5.1.3 The following human health and safety issues have been identified as key risks:

- Bird Strike Risk - Helicopters

3.5.1.4 Any deployment of artificial nest sites on offshore structures within proximity to a helipad, needs to consider the safety of flight operations and the risk assessment of bird strikes to aircraft in the vicinity of the proposed colony. The bird strike risk to aircraft using offshore structures can be expected to immediately rule out the vast majority of operational offshore structures associated with the wind, oil and gas industries as a location at which to deploy artificial nest sites. Moreover, the presence of a seabird colony attracts aerial predators such as the large gull species e.g. great black-backed gull, which themselves may be considered of a heightened bird strike risk. These predators loaf and fly above colonies waiting for opportunistic moments to attack. A bespoke tower located offshore away from

[2] http://www.ices.dk/marineworld/fishmap/ices/pdf/whiting.pdf

other installations would negate these risks.

- Disease concerns (from guano and from the birds themselves)

3.5.1.5 Feacal matter from gulls (Larus ssp.), is known to carry a range of pathogenic bacteria e.g. Campylobacters (Campylobacter jejuni), Clostridium perfringens, Escherichia coli, Listerias (Listeria monocytogenes), and Salmonellae (S. enterica & S. typhimurium) (Benskin et al. 2009; Fuirst et al. 2018). However, the risk to human health is mild (e.g. food poisoning symptoms which would last a few days and generally pose no long-term health risks).

3.5.1.6 On L8-P, personnel on the installation had concerns regarding bird flu in 2006, which resulted in the (unsolicited) removal of nests from the installation destroying the breeding attempt for that season (Camphuysen & Leopold 2007)

- Nesting material/guano

3.5.1.7 The actual risks associated with bird guano are largely limited to causing slippery surfaces which could cause trips/slips. A further concern is the accumulation of guano obscuring safety markings.

- Corrosion of platforms

3.5.1.8 Seabird guano is highly corrosive due to the contained uric acid and other chemical compounds contained within it of birds feeding in the marine environment (Goldstein 2002, Spennemann & Watson 2018). This corrosion may cause loss of structural integrity in some areas of the platform which could result in a risk to human safety. However, materials are available on the market which can mitigate this impact (see Christensen-Dalsgaard 2019).

- Noise / Smell

3.5.1.9 Some staff living on platforms alongside the birds may find the noise and smell disruptive.

3.5.1.10 Potential to limit/disrupt maintenance operations

3.5.1.11 Birds may also cause an inconvenience with regards to potential to limit or disrupt maintenance operations. The protection and management of wild birds, including kittiwake, falls under UK legislation that includes (but may not be limited to) the Wildlife & Countryside Act 1981 (as amended) and beyond 12 nm offshore, the Conservation of Offshore Marine Habitats & Species Regulations 2017. It is illegal to deliberately disturb nesting kittiwakes or, whilst it is being built or in use, destroy/damage/remove their nests and eggs. In consequence, this may result in the delay to planned maintenance or decommissioning works at a installation.

3.5.2 Human-bird interactions

3.5.2.1 By nesting on human structures the birds themselves may inadvertently experience issues due to:

Disturbance

3.5.2.2 Human disturbance of breeding Kittiwakes can negatively affect their chick production (Beale & Monaghan 2004) though the magnitude of the effect is disputable (Sandvik &

Barrett 2001, Reiertsen et al. 2018). Birds at some sites seem to habituate to regular patterns of human activities on installations (Christensen-Dalsgaard et al. 2019).

3.5.2.3 Nesting around oil and gas installations may put birds at risk from contamination from minor spills etc. Some of the birds observed at Heidrun were seen with small smudges of oil/dirt on the head but this appeared to be from touching the platform and they did not seem to be negatively affected (Christensen-Dalsgaard pers. comm.)

Offshore wind farm collision risk

3.5.2.4 The positioning of any artificial nest sites offshore needs to avoid or minimise inadvertently increasing the collision risk of kittiwake with existing and consented offshore wind developments. Considerations of future offshore energy sites would be factored in if and when locations become available.

Bird strike risk – helicopters

3.5.2.5 Birds nesting on structures which require helicopter operations are also at risk of collisions from helicopter activity. Helicopters can potentially cause significant disturbance to breeding birds (Chardine and Mendenhall 1998). However, birds may become habituated to regular overflights. In Scotland, Dunnet (1977) found nesting guillemots and kittiwakes did not show any significant flight responses to planes flying 100 m (330 ft) above the cliff where the birds were nesting. Non breeding birds are more likely to be flushed by disturbance at colonies (Chardine and Mendenhall 1998).

Decommissioning

3.5.2.6 Oil & Gas installations are temporary structures which will eventually have to be decommissioned. Current regulations mean birds are protected once they have started breeding, therefore decommissioning operations are usually restricted to the non-breeding season. This will obviously result in displacement of breeding adults for the following breeding seasons. The total number of birds currently nesting on offshore structures is currently unknown. However, there are known installations in the southern North Sea with existing populations of breeding kittiwake that are due to be decommissioned in the next few years.

3.5.2.7 Orsted surveys carried out in 2021, included a partially decommissioned structure which had previously supported a sizable population of breeding kittiwake, even though the topside had been removed birds returned to the site and were found breeding on ledges on the leg struts. This along with similar situations onshore e.g. Gateshead kittiwake tower and Boulogne Sur Mer wall (see NIRAS 2020), provides evidence that birds are likely to return to an established site and breed on a new structure or what remains of the structure, in this case colonisation of a new site is likely to occur quickly i.e. within a breeding season.

3.5.3 Mitigation measures

3.5.3.1 Efforts are made to deter birds from many offshore installations. For the current study, the reverse is the desired outcome for kittiwakes. However, some deterrent features may need to be incorporated to structures to dissuade populations of large gulls building up on the installations, to reduce predation pressure on nesting kittiwakes.

3.5.3.2 The Heidrun installation is an example of where there have been some issues with nesting kittiwakes in areas where maintenance was required. In this case, the company early in spring covered those areas of concern with netting to avoid returning breeding birds establishing there, which proved to be at least partly successful (Christensen-Dalsgaard pers. comm.)

3.5.3.3 With regards to creating potential nesting sites offshore, many of the above mentioned human-bird and bird-human conflicts would be irrelevant as it is unlikely any artificial sites would be installed on operational manned installations. However, structures are likely to require infrequent visits for monitoring and maintenance purposes. Structures can be designed to minimise disturbance by those visiting for the purposes of monitoring breeding birds whether for visual observations of the individual nests, or handling of adults and chicks for research purposes. Monitoring to assess population numbers and breeding success of the colony can also be carried out from a distance using methods such as drones, which would further minimise on human disturbance. Routine maintenance work would need to be carried out during the non-breeding season for kittiwake.

Conclusion	Context
The main issues arise from birds conflicting with human presence/activities on structures, these have the potential to disrupt breeding and reduce productivity of birds.	A purpose built unmanned structure would mitigate against most of the risks mentioned above. However, to reduce the impact of collision risk from nearby Offshore Wind Farms and, Oil and Gas operations, the location of the structure will be key.

3.6 Assessment of optimum design (and location) specification based on nest site characteristics at existing offshore installations

3.6.1.1 In deploying artificial nest sites offshore in the North Sea, whether it be to a new or existing structure, it can safely be assumed that connectivity across the region already exists to facilitate initial colonisation by prospective breeders.

3.6.1.2 Table 4 summarises the key features of an ideal offshore nesting site that are likely to lead to successful colonisation and colony establishment.

Table 4. Key location and design features for offshore nesting sites based on this review. Text in italics represents features which are thought to be important from visual observations (though have not been scientifically tested/reported).

	Feature	Optimal location/design
Location:	Connectivity	All North Sea
	Proximity to reliable food resources	Southern North Sea close to fronts
	Connectivity/Proximity	Areas with growing colonies – near any known offshore sites e.g. southern North Sea Oil/Gas fields
Structure:	Design – Visual appearance and foundations	Does not matter – floating/ fixed base, as long as ledges exist and food is available nearby.
	Height	<10 m* above sea surface at MHWS (* location dependent i.e., above wave splash zone, c.10-20m)
	Water Depth	Does not matter, proximity to food sources more important.
	Ledges	Width of 15 - 25 cm Near vertical back wall
	Aspect	Leeward side of structures Outward (seaward) facing
	Small scale design features	*Situated under platforms/ with small roof/side walls for shelter and protection from predators*
	Disturbance	*Low human disturbance within proximity to the artificial colony, and ideally an unmanned structure* *Minimise predation opportunities (avoid providing areas where large gulls can congregate)*
Additional considerations:	Monitoring & Maintenance	Accessibility Visibility of nests for surveillance of colony from the platform, boat and/or drone
	Risk Factors	Proximity to existing/planned (1) Offshore Wind Farms (collision risk) and (2) helicopter operations (collision risk)

3.7 Potential to deliver on compensation for the Adverse Effect on Site Integrity

3.7.1.1 This evidence report suggests that the provision of additional offshore nesting sites for kittiwake could be an adequate compensatory measure to offset the impact of Hornsea

Four to the kittiwake feature of the FFC SPA. Kittiwakes readily utilise man-made structures located offshore and therefore it is considered that the establishment of artificial nest sites would provide a viable compensation option. Theoretically, successful establishment of breeding colonies at these sites would produce young that would become part of the wider Eastern Atlantic population of kittiwake. Thereby maintaining the coherence of the network of SPAs designated, at least in part, for kittiwake.

3.7.1.2 The predicted impact for Hornsea Four and the relevant breeding population required to provide a comparable number of young that would survive to adulthood to offset the impact of Hornsea Four is presented in **B2.6 RP Volume B2 Chapter 6 Compensation measures for FFC SPA Overview Table 2**. Although the impact from Hornsea Four alone is not likely to be sufficient to cause an adverse effect on the integrity of the FFC SPA, when taken together with the effects of other plans and projects in-combination, an AEOI may not be ruled out.

3.7.1.3 A feasible strategy to deliver compensation is to provide additional breeding opportunities for kittiwake such that the overall breeding population is maintained. It is known that kittiwake will nest on man-made structures offshore and so this review has considered whether it is possible to:

- Create artificial nesting sites offshore that would be used by breeding kittiwakes; and
- Specify the high-level design, location and scale of those sites sufficient to offset the predicted impact.

3.7.1.4 On the basis of this review it is considered that it is feasible to provide artificial nesting sites offshore to provide additional breeding habitat for kittiwakes. There are successful examples of sites where kittiwakes have opportunistically made use of existing man-made structures to successfully breed, and the only limitation to population size is the number of available nesting spaces. To date, no sites have been designed specifically for this purpose in an offshore location but sites designed for this purpose onshore have been successful. These sites typically support self-sustaining breeding populations within a relatively short period of time. A purpose built structure offshore is likely to result in a larger and more productive colony than modifying existing platforms to accommodate nesting kittiwakes. This is based on the assumption that the former structure would have less conflicting issues arising from the scale at which to maintain health and safety standards and the absence of routine working operations.

3.7.1.5 It is known that young kittiwakes will disperse and potentially make use of other breeding locations. A relatively small proportion (as few as 11%) tend to remain at their natal sites (and thus create the basis for the development of a sustainable additional colony) with the remainder finding other breeding sites.

3.7.1.6 It is expected that the majority of young produced by birds nesting at additional artificial sites will provide additional recruits to the east Atlantic biogeographic population, which in turn provides the breeding adult birds that colonise the cliffs of the FFC SPA as well as other colonies on the east coast of England. If sufficient additional breeding can be encouraged then the overall breeding population, including potentially that at the FFC SPA will increase by at least the same amount as that predicted to be lost through collision mortality.

3.7.1.7 On the basis of this review, it is considered that the creation of artificial nesting structures can support nesting kittiwakes to produce sufficient young that will in turn mature and disperse to provide additional breeding adult birds in the population to fully offset the potential impact of collision mortality of kittiwakes (as presented in **B2.6 RP Volume B2 Chapter 6 Compensation measures for FFC SPA Overview Table 2**) at Hornsea Four. This approach will be sustainable for at least the lifetime of Hornsea Four offshore wind farm and hence the period within which collision mortality would occur.

3.8 Conclusion (Kittiwake)

3.8.1.1 Kittiwakes will utilise artificial nesting structures and colonise man-made offshore structures. It is therefore considered that the establishment of artificial nest sites offshore would provide an appropriate compensation option to offset the collision impact associated with Hornsea Four. The establishment of breeding colonies at these sites would produce young that would become part of the wider Eastern Atlantic population of kittiwake.

3.8.1.2 The predicted impact for Hornsea Four and the relevant breeding population required to provide a comparable number of young that would survive to adulthood to offset the impact of Hornsea Four is presented in **B2.6 RP Volume B2 Chapter 6 Compensation measures for FFC SPA Overview Table 2**.

3.8.1.3 The southern North Sea would be the most suitable location in terms of connectivity with the FFC SPA population and meeting habitat requirements. There will be a number of other site-specific factors (including design, orientation and accessibility) that should be taken into account after a site is selected. Locations where an existing structure with a successful breeding population of kittiwakes has already been established but is due to be decommissioned could present a viable opportunity to increase kittiwake populations in the area. Designs which would increase existing nesting capacity could be applied, and fine-scale features could be added that are likely to increase breeding success of established pairs using the site.

4 Northern Gannet

4.1 Northern Gannet threats and national population trends

4.1.1.1 Northern Gannet populations in the UK are increasing at a rate of around 2% per annum, with an increase of 34% between census in 2003-04 and colonies surveyed in 2013-15 (JNCC 2020). Due to the growing population trajectory, the species faces few threats which are likely to cause population level declines. However, UK Northern Gannet colonies show classic density dependence, where competition for resources (likely either prey or nesting space; Lewis et al., 2001) is more intense at larger colonies, limiting their population growth (i.e. approaching carrying capacity; **Figure 6**; Wanless et al., 2005). Construction of artificial nesting structures offers a potential avenue to maintain national Northern Gannet population growth by establishing attractive, low-competition colonies while compensating for wind farm mortality.

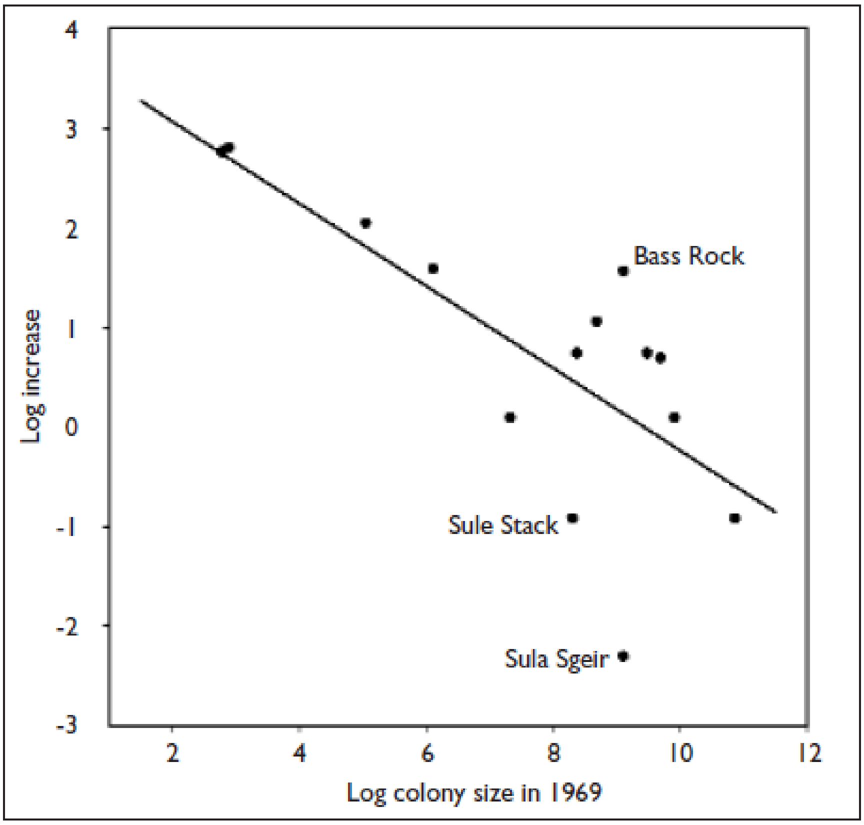

Figure 6. Log-log plot of rates of change in numbers of Northern Gannet at British and Irish colonies between 1969 and 2004 against colony size in 1969. The line represents density dependence, where larger colonies (in 1969) have lower growth. Figure from Wanless *et al.* (2005).

4.1.1.2 It should be noted however, that the Flamborough and Filey Coast SPA shows no indication of approaching carrying capacity (a plateau in population growth), and since it's colonisation in the 1950's has increased from 169 pairs in 1977 to 3,940 Apparently Occupied Nests (AONs) in 2004, to 7,859 AONs in 2009, and up to 11,061 AONs in 2012 (Nelson 1978; Joint Nature Conservation Committee, 2013).

4.2 Evidence of gannet colonising artificial structures

4.2.1.1 The literature review revealed numerous studies of gannet nesting on artificial (man-made) structures (Table 5). Although smaller and rarer compared to natural gannet colonies, the examples presented here provide compelling evidence that gannet are not discouraged from establishing and maintaining colonies on artificial structures.

4.2.1.2 Firstly, the literature review was expanded to include the three species of the gannet genus Morus, which yielded important findings from the Australasian gannet Morus serrator. Given the small size of the genus and their physiological and behavioural similarities, evidence of nesting on artificial structures from one species is considered to be applicable to the genus as a whole.

4.2.1.3 Australasian gannet provides the only evidence of gannet colonising artificial structures offshore. A colony established on an old support structure of a decommissioned lighthouse at Margret Brock Reef is located 8 km offshore of Cape Jaffa on the South Australian mainland. There is no published scientific literature on this colony but it appears to have been established on the structure after the lighthouse was removed in 1976 and appears to hold 100-200 nests (estimated from pictures in Eremorphila 2014).

4.2.1.4 Better studied examples come from Australasian Gannet colonisation of several artificial structures in Port Phillip Bay, Victoria, Australia. The Wedge Light colony was established on a flat wooden landing platform 3 km offshore, and grown from its inception in 1966 (at least three nests) to up to 50 nests in the 1988–92 period. Removal of a central hut increased the potential breeding area, and in 1997 the platform held 58 nests, including two on structural cross beams under the platform (Norman et al., 1998). The Pope's Eye colony started on a similar flat wooden landing platform approximately 3 km offshore. By 1985 there were 25 nests, which were in part established by birds from nearby Wedge Light, and in 1988 there were 46 active nests. After construction of a new platform and walkway the colony expanded to 120 nests by 1992 and continued to increase onto surrounding artificial rocks up to 140 nests in 1994 (Norman et al., 1998). A further four colonies, all on artificial structures, are known to have established since Wedge Light and Pope's Eye in Port Phillip Bay (**Figure 7**). These take the form of channel navigation markers and an artificial concrete caisson, providing platform areas of between four and 45 m^2 which are used for nesting (Norman 2001).

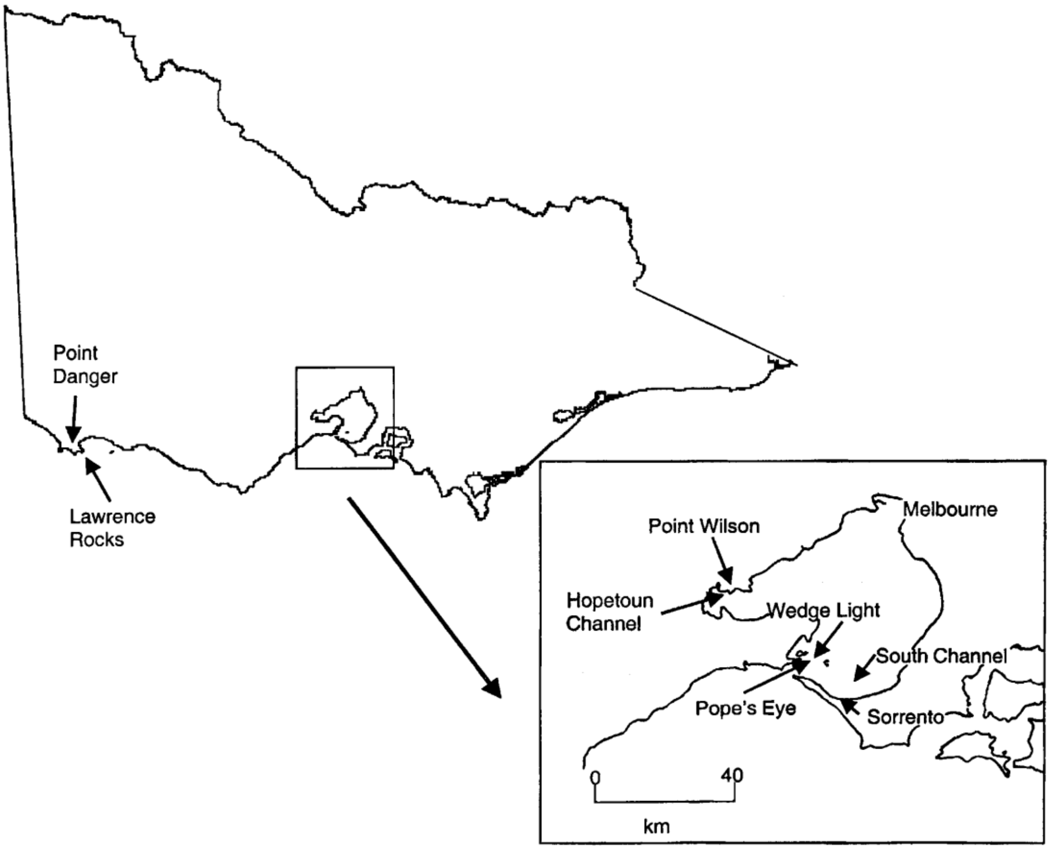

Figure 7. Map of Victoria, Australia showing location of established Lawrence Rocks Australasian Gannet colony (2,463 pairs) and inset showing colonies established on artificial structures in Port Phillip Bay. Map from Norman (2001).

4.2.1.5 Northern Gannet have also been recorded colonising coastal artificial structures in several countries. On the French Mediterranean coast breeding attempts have been made by individual pairs and groups of birds (<10) in several harbours. At Sausset-Les-Pins between 1995 and 2005, five to seven individuals attempted to breed (in some years successfully) on boats and jetties, with a custom-made floating platform created for them in 2004 (Renaud et al., 2006). Five kilometres from Sausset-Les-Pins, the harbour of Carry-le-Rouet has also seen breeding attempts since 2006. A pair and several solitary birds (one of which was banded in the UK) first occupied jetties before a floating platform was added. Two pairs have successfully raised chicks over the years, with one fledgling returning as an adult (Deideri et al., 2014). In Italy a pair have attempted to breed on small boats (either on top of their covers or on decks) in the harbour of Porto Venere, and successfully raised a chick in 2015 (Giagnoni et al., 2015). Single birds have built nests on artificial structures, and returned over multiple years, in Denmark (occupying a harbour quay) and England (occupying a house chimney).

4.2.1.6 The colonisation of French and Italian harbours by Northern gannet and Port Phillip Bay by Australasian Gannet demonstrate an apparent preference for artificial structures given the availability of apparently suitable natural sites to colonise. Giagnoni et al. (2015) notes "This choice of nesting sites probably did not depend on unavailability of natural habitat in the area; in fact the terraced cliffs of Palmaria Island and the promontory of Porto Venere appeared suitable". At Carry-le-Rouet Northern Gannet were encouraged away from the jetties chosen for nesting in the harbour (using wooden silhouette decoys) to a neighbouring natural site but chose to remain. The Australasian Gannet colonisation of artificial structures in Port Phillip Bay was fuelled through immigration from birds from the nearest large colony of Lawrence Rocks (2,463 pairs; Norman 2001). However, there is approximately 300 kilometres of seemingly suitable nesting coastline (headlands and islands) between Lawrence Rocks and Port Phillip Bay (**Figure 7**), why a nearer, natural site was not colonised in preference to artificial structures at the gateway to Melbourne harbour is unknown. Immigration from Lawrence Rocks also likely established the Australasian Gannet colony on the ex-lighthouse support structure at Margret Brock Reef, approximately 260 km to the west, again, seemingly in preference to suitable natural habitat.

4.2.1.7 No gannet nesting on artificial structures was recorded during a recent offshore survey of 32 oil and gas platforms in the southern North Sea (NIRAS 2021). It is possible that the absence of gannet nests could be due to the unsuitability of structure for gannet (e.g. narrow girders) or human invention (e.g. gannets not wanted on helideck).

Table 5. Evidence of gannet colonising artificial structures

Species	Location	Structure	Position	Colony size	Reference
Australasian Gannet	Wedge Light, Victoria, Australia	Wooden platform ($25m^2$)	~ 3 km offshore	Established in 1966. 58 nests in 1997	Norman *et al.* (1998); Norman (2001); Gibbs *et al.* (2001)
Australasian Gannet	Pope's eye, Victoria, Australia (38°16′42″S, 144°41′48″E)	Wooden platforms, with expansion onto concrete structures and artificial rocks	3 km offshore	Established in 1985. 140 nests in 1997	Norman *et al.* (1998); Norman (2001); Gibbs *et al.* (2001)
Australasian Gannet	Margret Brock Reef, South Australia	Metal jetty support structure for decommissioned lighthouse	8 km offshore	~100-200 nests	Eremorphila (2014)
Northern Gannet	Sausset-Les-Pins, Provence, France	Concrete harbour jetty and floating platform	onshore	7-9 birds in 1995	Renaud *et al.* 2006
Northern Gannet	Carry-le-Rouet, Provence, France	Concrete and wooden harbour jetties and floating platform	onshore	2 pairs successfully reared chicks in 2013	Deideri *et al.* 2014
Northern Gannet	Porto Venere, Italy	Harbour boats	onshore	A pair successfully raised a chick in 2015	Giagnoni *et al.* 2015
Northern Gannet	Christiansø, Denmark (55°19′N 15°11′E)	Concrete harbour quay	onshore	Adult nest building 2013-2015	Lyngs (2015)
Northern Gannet	Seaford, East Essex, UK	House chimney	onshore	Adult nest building 1997-2000	Palmer (2001)

Figure 8. Australasian Gannet breeding at Margret Brock Reef, South Australia. Image from Eremorphila (2014).

Figure 9. Australasian Gannet breeding at Pope's Eye, Victoria, Australia. Image from The Nature Conservancy Australia (2021).

Figure 10. Northern Gannet breeding at Sausset-Les-Pins, Provence, France in 2004. Image from Renaud *et al.* (2006).

Figure 11. Northern Gannet breeding at Carry-le-Rouet, Provence, France in 2009. Image from Deideri *et al.* (2014).

Figure 12. Northern Gannet breeding at Carry-le-Rouet, Provence, France in 2012. Image from Deideri *et al.* (2014).

Figure 13. Northern Gannet breeding at Porto Venere, Italy. Image from Giagnoni *et al.* (2015).

Figure 14. Northern Gannet breeding Christiansø, Denmark in 2013. Image from Lyngs (2015).

Figure 15. Northern Gannet breeding at Seaford, East Sussex in 2000. Image from Palmer (2001).

4.3 Feasibility of establishing new gannet colonies

4.3.1 Overspill, colonisation and population growth

4.3.1.1 The pace of gannet colonisation (of a new colony on natural habitat or an artificial structure) is largely influenced by the size and vicinity of established colonies. Population growth can be rapid at a new colony when a large population exists locally to fuel immigration. Northern Gannets colonised Lambay Island in Ireland in 2006 and by 2013 there were 728 AONs, similarly Northern Gannets colonised Sule Skerry in Scotland in 2003 and by 2018 there were 4,515 apparently occupied sites (Harris et al., 2019). In both cases a large established gannetry occurred nearby (Lambay Island 10 km from Irelands' Eye; Sule Skerry 8 km from Sule Stack) which 'seeded' the new colony and fuelled its early growth (confirmed by ringing recoveries; Harris et al., 2019). By contrast the Bempton colony established in England is thought almost certain to have been founded by birds from Bass Rock (Nelson 1978). Despite the large size of the Bass Rock colony, it is located approximately 270 km from Bempton and initial stages of population growth were slow: one or two pairs were recorded at Bempton from the 1920s through to 1951, which gradually increased to around 12 pairs in 1963, and up to 21 apparently occupied sites in 1969. By 1977, 169 nesting pairs were recorded, and Bempton has continued rapid growth to the present day (Nelson 1978). Nelson (1978) suggests that new colonies need to reach a critical mass of breeding birds, at which point behavioural and social stimuli increase the "tempo of activity" in the colony (increased breeding success, earlier colony return, laying and fledging, and greater numbers of immature birds). This is important as new gannet colonies are sustained by immigration rather than their own reproductive output until they reach about 620 nests (Moss et al., 2002), and more attractive new colonies with higher immigration will reach a self-sustaining population faster (**Table 6**).

Table 6. Years between colonisation and reaching a population of 620 pairs, nests or sites by Northern Gannet colonies in the Northeast Atlantic. + indicates still to reach this size. Table from Harris *et al.* (2019)

Colony, Country	Years
Sule Skerry, Scotland	6
Lambay, Ireland	7
Westray, Scotland	9
Storstappen, Norway	9
Buholmene, Norway	10+
Troup Head, Scotland	11
Fair Isle, Scotland	12
Foula, Scotland	14
Hermaness, Scotland	14
Ortac, Channel Islands	16
Skarvklakken, Norway	17
Noss, Scotland	19
Clare Island, Ireland	19+
Rouzic, France	21
Helgoland, Germany	22
Flannan Isles, Scotland	22
Hovsflesa, Norway	23+
Ireland's Eye, Ireland	25+
Runde, Norway	31
Scar Rocks, Scotland	43
Syltefjord, Norway	47
Great Saltee, Ireland	57
Bempton, England	61

4.3.2 Social attraction to increase rate of colonisation

4.3.2.1 Using artificial decoys and audio playback of calls has been attempted to improve gannet colonisation. Re-colonisation of an extirpated Northern Gannet colony on Ile-aux-Perroquets, Quebec was attempted using decoys and playback. Several birds landed within the decoy colony; however, the project was abandoned after 6 seasons due to the lack of prospecting individuals, despite a large number of birds in the vicinity of the colony site (Sayer & Fogle 2013). In New Zealand similar techniques have been used to attract Australasian Gannet to colonise new sites at Mana Island and Mapiri Peninsula but have not been successful. A third attempt at Young Nick's Head deployed decoys and playback in 2008 and had two eggs reported in the 2010 breeding season, 11 chicks fledged in the 2011 breeding season and 28 chicks fledged in the 2012 breeding season (Sayer & Fogle 2013). This site was thought successful due to its proximity (250 km) to the large Cape Kidnappers gannet colony, from which birds frequently transit past, and its physical similarity (on the edge of a 30 m cliff of an exposed headland) to Cape Kidnappers (Sayer & Fogle 2013).

4.3.2.2 Social attraction by other breeding seabirds may also be important for improving gannet colonisation. Northern Gannet colonisation of Sule Skerry and Westray, Scotland was first recorded in 2003 with gannets nests amongst those of Common Guillemot (Wanless et al., 2005).

4.4 Conclusion (Northern Gannet)

4.4.1.1 This report has reviewed the evidence of gannet nesting on artificial (man-made) structures and the feasibility of establishing new gannet colonies. The numerous examples of Australasian and Northern Gannet colonising artificial structures (supports, jetties, boats, platforms) provides real-world evidence of the phenomenon, and suggests that gannet do not have a clear preference for natural habitat colonies. Examples of colonisation in high-human-disturbance European harbours and on offshore (3-8 km from mainland) Australian structures demonstrate the breadth of gannet colonisation of artificial structures.

4.4.1.2 The feasibility of establishing new gannet colonies (on artificial structures or in natural habitat) relies heavily on the choice of geographical location, and in particular the vicinity of a large, established gannet colony. Immigration from such a large nearby colony has seen rapid population growth at new, naturally-established colonies in the UK (reaching 620 pairs in under 7 years when proximity of <10 km). However, colonisation of artificial structures in Port Phillip Bay and Margret Brock Reef, Australia has still been observed at distances of approximately 260-300 km from an established colony, and Northern Gannet colonisation of harbours in the Mediterranean occurs at the edge of the species' breeding range, well away from any large colonies. Gannet appear responsive to artificial attraction (decoys and playback) at new colonies, but this measure is secondary to selecting a good geographical location.

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Appendix A

Survey Report from the June Boat Based Survey of nesting birds of oil and gas platforms in the southern North Sea

1 Introduction

1.1.1.1 NIRAS were commissioned to undertake vessel based bird surveys in June 2021 around a number of offshore installations in the SNS region to help inform these derogation measures. Agreements and contracts were sought from two oil and gas operators and permission was granted for vessel access to 16 platforms around the Hornsea project areas (see **Figure A 1**). Due to the nature of these agreements the platform identities and owners must remain anonymous and as such a numbering system has been assigned to them for the purpose of this report.

1.1.1.2 The primary aim of the survey work was to acquire baseline information on seabird nesting at a selection of O&G platforms relevant to Hornsea Four, with the following objectives;

- To gain quantitative information on the population size of kittiwake colonies on a number of installations spread across the SNS
- Map nests and note the status of birds at all surveyed locations and photograph for documentation
- Document information on the nesting site preferences of birds at occupied installations e.g. aspect, location, ledge size etc
- Document features and photograph installations where kittiwakes are absent to compare and contrast with occupied sites
- Add to Orsteds' presence/ absence database by assessing other installations (where survey agreements have not been pursued) for breeding birds from outside safety exclusion zones while in transit.
- Note the presence of other species of seabird breeding / using platforms.

1.1.1.3 The information gathered is intended to support the case for offshore artificial nesting sites as a derogation measure for Hornsea Four in relation to kittiwake impacts on FFC SPA. The information gained will be assessed in relation to enhancing our understanding of factors influencing the distribution of kittiwake breeding sites in the offshore environment to inform future site selection processes and design principals.

2 Survey Operations

2.1.1.1 Surveys were successfully undertaken at all 16 proposed sites during a 4 day survey window from 11th June 2021 to 15th June 2021. A detailed breakdown of operations during this period is presented in **Table A 1**. Weather and sea conditions were good throughout the survey period with no survey days lost / postponed due to poor environmental conditions (see **Table A 2**). Sea states were highly favourable for surveys during the survey period (see **Figure A 2**). On day 1, 3 and 4, the sea state did not rise above a state 3. The sea state picked up to a state 3-4 on day 2 which made using the telescope (30-70 x 95) with tripod for surveying impractical, however conditions were still acceptable for surveys to be carried out using binoculars and confidence in counts in these conditions were still high.

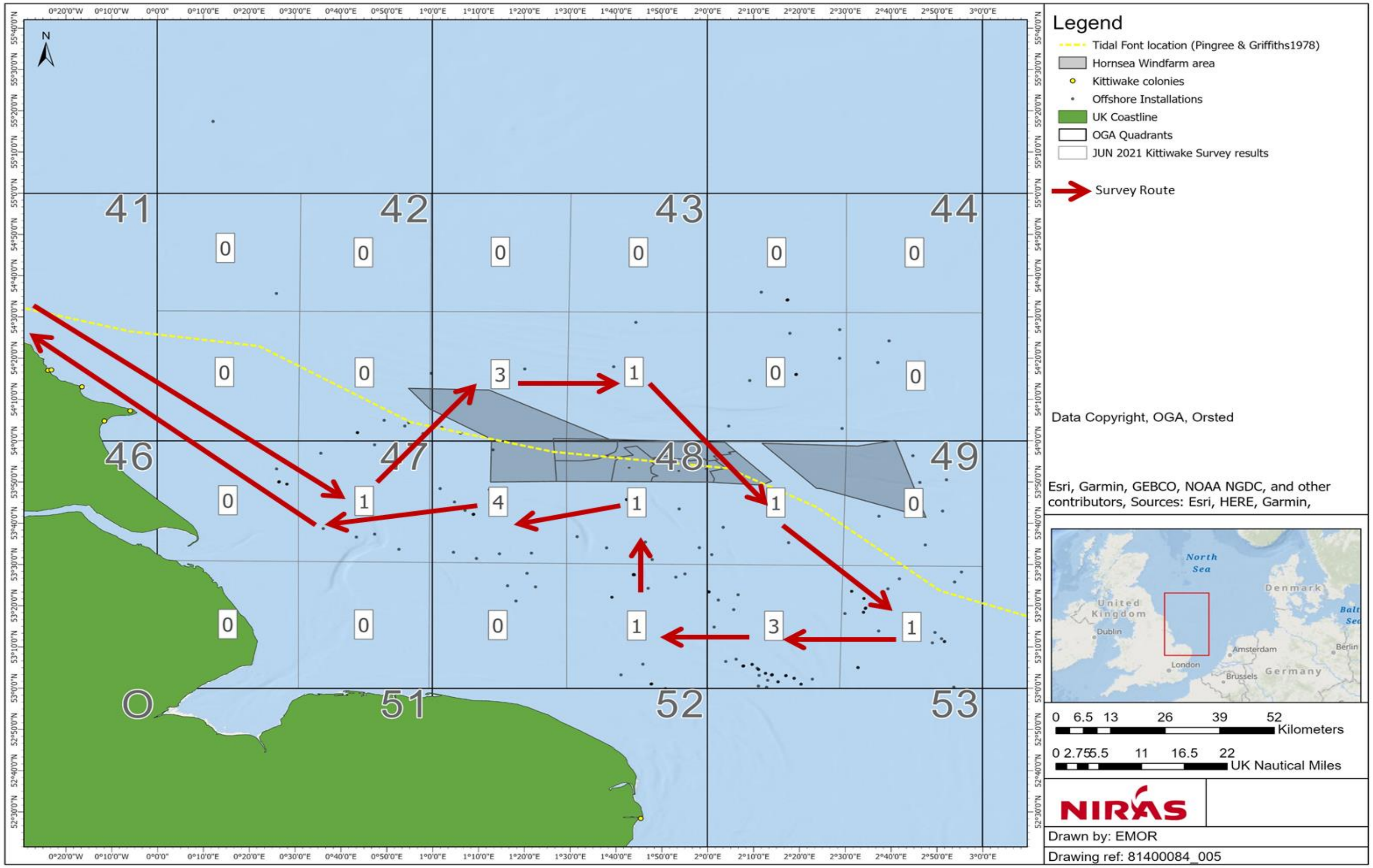

Figure A 1: Survey route showing number and spread of platforms surveyed (white boxes) within each OGA block.

Table A 1: Summary of survey operations 11 June – 15 June 2021

Summary of operations: HOW04 Offshore Seabird Census Survey

Vessel: DSV Curtis Marshall ***Survey Location: Offshore - North Sea***

Date	TIMES (BST)		DIARY OF OPERATIONS	notes
	From	*To*		
11/06/2021	00:00	06:00	Resting	
	06:01	06:30	Boarding	
	06:31	07:00	Essential safety briefing and depart port due to tides	
	07:01	13:30	Transit to installation one -UKSNS01, safety drills undertaken, safety meetings held.	
	13:31	14:30	VSat / communication & data issues - transit towards coast to reach Wi-Fi/Comms to sort out issue - Off Flamborough Head	
	14:31	17:30	Attempts to fix sat issue to be tested offshore -	
	17:31	18:30	Transit back to installation #1 - UKSNS01	
	18:31	18:45	Internet data bandwidth still unavailable - attempts to rectify unsuccessful. No access within 500m of platform without ability to send across signed permits immediately prior to entry of exclusion zone.	
	18:46	19:30	Survey of installation #1 -UKSNS01 from beyond 500m exclusion zone	Sea conditions good – use of telescope possible - Small number of breeding birds present
	19:31	20:00	Holding off installation #1 -UKSNS01 area to try and get necessary permits sent to platform - unsuccessful	
	20:01	20:55	Transit back to range of non-sat communications - Flamborough Head	Vessel VSat issues
	20:56	23:59	Resting in area off Flamborough	
12/06/2021	00:00	05:00	Resting / Transit back to installation #1 -UKSNS01	
	05:01	06:10	Holding off platform, awaiting permissions due to connectivity issues	
	06:11	08:00	Survey within installation #1 500m exclusion called off due to internet/comms issues - Transit installation #2 - UKSNS02	
	08:01	08:50	Survey of installation #2 -UKSNS02 at 500m distance	Birds present not breeding
	08:50	09:24	Awaiting sign off for permit to enter exclusion zona at installation #2	
	09:25	09:43	Survey installation #2 -UKSNS02 within exclusion zone	
	09:44	11:30	Transit to installation #3 - UKSNS03	

Summary of operations: HOW04 Offshore Seabird Census Survey

Vessel: DSV Curtis Marshall ***Survey Location: Offshore - North Sea***

Date	TIMES (BST)		DIARY OF OPERATIONS	notes
	From	*To*		
	11:31	12:30	Survey at 500m installation #3 - UKSNS03, while awaiting sign off for permit to enter exclusion zone at installation #3 - UKSNS03	
	12:31	12:50	Survey installation #3 - UKSNS03 within exclusion zone	Birds present not breeding
	12:51	15:20	Transit to installation #4 - UKSNS04	
	15:21	15:50	Survey installation #4 - UKSNS04 at 500m and within exclusion zone	No breeding birds
	15:51	16:51	Transit to installation #5 - UKSNS05	
	06:52	17:06	Survey installation #5 - UKSNS05 at 500m and within exclusion zone	No breeding birds
	17:07	23:59	Transit to installation #6 - UKSNS06 (overnight) / Resting	
13/06/2021	00:00	05:00	Resting / Transit to installation #6 - UKSNS06	
	05:01	05:39	Holding off installation #6 - UKSNS06 platform, awaiting permissions	
	05:40	06:53	Survey within installation #6 - UKSNS06 500m exclusion zone	Breeding birds present
	06:54	08:10	Transit to installation #7 - UKSNS07	
	08:11	08:25	Survey installation #7 - UKSNS07 within exclusion zone	No breeding birds
	08:26	10:19	Transit to installation #8 - UKSNS08	
	10:20	14:50	Survey installation #8 - UKSNS08 within exclusion zone	Breeding birds present
	14:51	16:00	Transit to installation #9 - UKSNS09	
	16:01	16:15	Holding off platform, awaiting permissions	
	16:16	16:30	Survey installation #9 - UKSNS09 within exclusion zone	No breeding birds
	16:31	16:34	Transit to installation #10- UKSNS10	
	16:35	16:45	Survey installation #10 - UKSNS10 within exclusion zone	No breeding birds
	16:46	18:41	Transit to installation #11 (complex of 5 platforms) - UKSNS11 COMPLEX	
	18:56	20:52	Begin surveys at installation #11 UKSNS11 F - N and E side completed before low light conditions prevented further work	Breeding birds present
	20:53	23:59	Resting / Holding off in area around installation #11 - UKSNS11 field	
14/06/2021	00:00	05:00	Resting	
	05:01	06:50	Survey rest of installation #11 complex - UKSNS11 platform	Breeding birds present
	06:51	08:09	Transit to installation #12 - UKSNS12	
	08:10	10:30	Survey installation #12 - UKSNS12	Breeding birds present –

Summary of operations: HOW04 Offshore Seabird Census Survey

Vessel: DSV Curtis Marshall ***Survey Location: Offshore - North Sea***

Date	TIMES (BST)		DIARY OF OPERATIONS	notes
	From	*To*		
				kittiwake and potential for guillemot and Razorbill
	10:31	11:11	Transit to installation #13 - UKSNS13	
	11:11	11:30	Survey installation #13 - UKSNS13	No breeding birds
	11:31	12:20	Transit to installation #14 - UKSNS14	Legs only – rest of platform decommissioned.
	12:21	13:15	Survey installation #14 - UKSNS14	Breeding birds still present
	13:16	14:40	Transit to installation #15 - UKSNS15	
	14:41	15:35	Survey installation #15 - UKSNS15	Breeding birds present
	15:36	14:09	Transit to installation #16 - UKSNS16	
	16:10	20:30	Survey installation #17 - UKSNS16	Breeding birds present
	20:31	23:59	Transit to port at Hartlepool overnight/ resting	
15/06/2021	00:00	05:59	Transit to port at Hartlepool overnight/ resting	
	06:00	06:30	Arrive at Port - Hartlepool	
	06:30	09:30	Demobilisation	

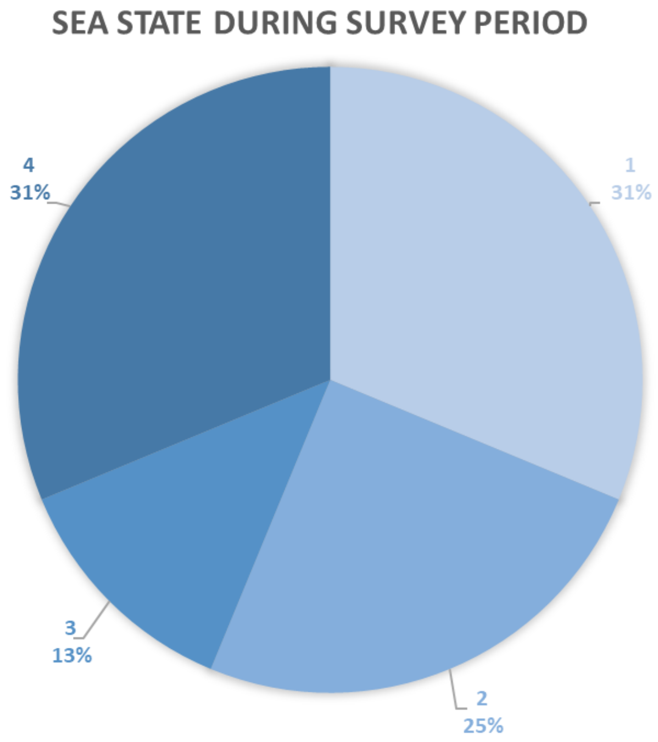

Figure A 2: Summary of sea sate conditions experienced during survey period.

Table A 2: Environmental conditions during survey period.

Date	Daylight	Time period	Observed Weather Conditions on Site	Surveying Yes/ No
11/06/ 2021	*Sunrise*:	00:01 - 06:00	wind: W 4-5, Vis good, Sea state 0.2 m swell , vis - excellent	No
	04:44	06:01 - 12:00	wind: W 4-5, Vis good, Sea state 0.2 m swell, vis - excellent	No
	Sunset:	12:01 - 18:00	wind: W 4-5, Vis good, Sea state 0.2 m swell, vis - excellent	No
	21:17	18:01 - 00:00	wind: W 5, Vis good, Sea state 0.4 m swell, vis - excellent	Yes
12/06/ 2021	Sunrise:	00:01 - 06:00	wind: W 5, Vis good, Sea state 0.4 m swell, vis - excellent	No
	04:44	06:01 - 12:00	wind: W 4-5, Sea state 4, <2 m swell, sunny, vis - excellent	Yes
	Sunset:	12:01 - 18:00	wind: W 3, Sea state 4, <2 m swell, sunny, vis - excellent	Yes
	21:18	18:01 - 00:00	wind: W 3, Sea state 4, <2 m swell, sunny, vis - excellent	No
13/06/ 2021	sunrise:	00:01 - 06:00	wind: SW 3-4, Sea state 1, <1 m swell, vis - excellent	Yes
	04:44	06:01 - 12:00	wind: S 2, Sea state 1, <2 m swell, sunny, vis - excellent	Yes
	Sunset:	12:01 - 18:00	wind: S 2, Sea state 1, <2 m swell, sunny, vis - excellent	Yes

Date	Daylight	Time period	Observed Weather Conditions on Site	Surveying Yes/No
	21:19	18:01 - 00:00	wind: SE 3, Sea state 1, <2 m swell, sunny, vis - excellent	No
14/06/2021	sunrise:	00:01 - 06:00	wind: SE 3, Sea state 3, <1 m swell, vis - excellent	No
	04:44	06:01 - 12:00	wind: SE 3, Sea state 3, <1 m swell, vis - excellent	Yes
	Sunset:	12:01 - 18:00	wind: SW 3, Sea state 1-2 , <1 m swell, vis - excellent	Yes
	21:20	18:01 - 00:00	wind: N 1, Sea state 1, <2 m swell, vis - excellent	Yes

2.2 Issues / Incidents

2.2.1.1 Very small aperture terminal (VSAT) communication issues were experienced during day 1 and day 2 of the survey period, this prevented the ability of the vessel to obtain the necessary permit and access requirements specified by operators to enter within the 500 m exclusion zones of platforms. Weather conditions on day 1 were good enough to allow surveys to be undertaken of a platform from just beyond the 500 m zone using the telescope which provided adequate results. However, only a small number of kittiwakes were seen on the platform concerned and a nest was clearly visible on the outside of the platform structure. If conditions were poor or there were large numbers of breeding birds this methodology would not be feasible and is unlikely to provide accurate counts or allow for accurate mapping of nests.

3 Survey Methodology

3.1.1.1 Surveys were undertaken between the 11th – 14th June 2021 using methodologies in line with current JNCC and OPRED guidance (JNCC 2021[3] and Walsh et al. 1995[4]).

3.1.1.2 A count of 'apparently occupied nests' (AON[5]), trace nests (TR) and apparently occupied sites (AOS) were made at each installation. Counts of kittiwakes present but not breeding on and around the structure were also made, and the number of 1st calendar year (Immature) birds present was noted where possible. Additional species present in/around installations were also recorded. The accepted census units for kittiwake is the number of apparently occupied nests (AON).

3.1.1.3 The location of all visible nests were photographed and mapped onto diagrams of the installations at each site and the status (i.e. trace, incubating adults, eggs/chicks where visible) and number of adults present at each nest was noted. The vessel moved slowly around each installation at a distance of 100-500 m from the platform, where required, the vessel held off at certain positions to allow surveyors time to observe and record at each face of the installation. Surveyors aimed to view the section of the installation being surveyed from directly opposite each side, different vantage points on the vessel were used to achieve an optimum viewing position. At certain platforms birds were observed nesting

[3] JNCC (2021) Advice Note. Seabird Survey Methods for Offshore Installations: Black-legged kittiwakes.
[4] Walsh, P.M., Halley, D.J., Harris, M.P., del Nevo, A., Sim, I.M.W., & Tasker, M.L. (1995). Seabird monitoring handbook for Britain and Ireland.
[5] Defined as a well-built nest capable of containing eggs with at least one adult present

beneath structures so nest counts were made from lower decks looking upwards as this provided a better vantage point than positions directly level or above, as recommended by JNCC guidance.

3.1.1.4 As per operator H&S requirements, vessels were not permitted to hold off where the vessel could potentially be at risk of drifting onto the platform, conditions were assessed prior to entering the 500 m exclusion zones and for 'drift on' faces the vessel held off at the best angle possible for viewing the side from a drift off position and a single pass was made >250 m from the platform to allow for improved visibility of the section if required (see **Figure A 3** for details).

3.1.1.5 Installations were divided up according to aspect and distinguishing features to enable each section to be surveyed and mapped accurately and repeatably. Counts were made from each section of a colony/sub-colony and were cross checked with numbers of mapped nests. Locations and AON estimates were made and mapped for sections of the colonies which were not visible / only partially visible. The final total of confirmed AONs is reported as the population census count for each installation.

3.1.1.6 Surveys were largely conducted from the upper deck of the vessel using binoculars (spec 10 x 42). Images were taken using a DSLR camera with 70-300 mm image stabilised lens. Where the sea state and weather conditions allowed, a telescope (30-70x zoom, 95 mm objective lens) was used to aid the assessment of nest status. A first pass was generally made at each installation at a 500 m radius to aide in assessing the site prior to entering the exclusion zones.

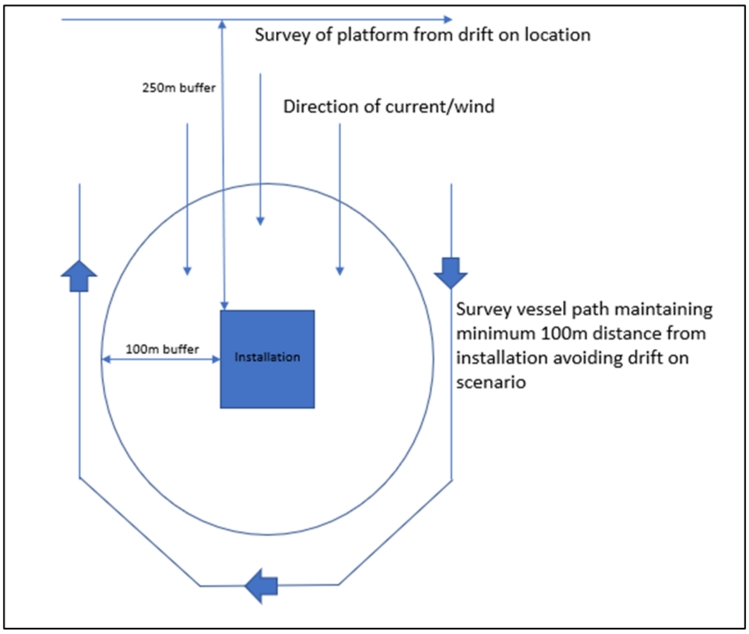

Figure A 3: Diagram showing survey positioning to avoid the risk of maintaining a 'drift on' position.

3.1.1.7 The time taken to survey installations varied with the type of installation, number of birds present, the location of nests on structures, weather conditions (see **Table A 3** below) and also length of time required to arrange permits to enter exclusion zones.

Table A 3: Survey duration and weather conditions during the surveys at each installation

Date	Platform ID	Survey start time	Survey duration (hours)	Breeding Kittiwake present[6]	Sea state	Swell	Wind	Visibility	Cloud cover	Rain	Sun
11 June	UKSNS01	18:45	00:45	Y	1	low	2 NW	excellent	3/8	1	Weak
12 June	UKSNS02	08:00	01:45	N	4	low	5 W	excellent	4/8	1	Mod
12 June	UKSNS03	11:30	00:30	N	4	low	4 W	excellent	1/8	1	Mod
12 June	UKSNS04	15:20	00:30	N	4	low	3 W	excellent	1/8	1	Mod
12 June	UKSNS05	16:52	00:14	N	4	low	3 W	excellent	1/8	1	Mod
13 June	UKSNS06	05:40	01:09	Y+	2	low	3 SW	excellent	0/8	1	Mod
13 June	UKSNS07	08:10	00:15	N	3	low	3 SW	excellent	0/8	1	Strong
13 June	UKSNS08	10:15	04:35	Y++	2	low	3 S	excellent	0/8	1	Strong
13 June	UKSNS09	16:15	00:15	N	1	low	2 S	excellent	0/8	1	Strong
13 June	UKSNS10	16:35	00:10	N	1	low	2 S	excellent	0/8	1	Strong
14 June	UKSNS11 (complex)	18:57	01:33	Y++	3	low	3 SE	good	3/8	1	Mod
14 June	UKSNS11 (complex)	05:10	01:40	Y++	3	low	5 S	good	1/8	1	Mod
14 June	UKSNS12	08:10	02:20	Y++	3	low	5 S	good	1/8	1	Mod
14 June	UKSNS13	11:15	00:15	N	2	low	3 SW	good	5/8	1	Mod
14 June	UKSNS14	12:25	00:50	Y+	1	low	3 SW	good	6/8	1	weak
14 June	UKSNS15	14:45	00:50	Y+	2	low	1 N	good	7/8	1	Weak
14 June	UKSNS16	16:10	04:15	Y++	1	low	1 N	good	7/8	1	weak

3.2 Issues / incidents regarding methodology

The survey methods above worked well and no issues or incidents occurred during surveys inside or outside the installations 500 m exclusion zones.

[6] Y= yes, N= no, + present in 10's, ++ present in 100's

4 Results

4.1.1.1 Sixteen installations (including one which was a complex with 5/6 platforms) were successfully surveyed from all visible angles, 15 at close range i.e. from within 500 m exclusion zones (plus one from outside the 500 m exclusion zone). In addition, 4 more installations were observed and photographed from a distance of 500 m – 1 km on passage, an estimation of bird presence / absence was gained from visual observations of 1-2 sides of each platform.

4.1.2 Offshore kittiwake populations

4.1.2.1 Breeding kittiwakes were observed on 9 of the platforms surveyed and found breeding in good numbers (100+) at 4 installations. Kittiwakes were observed on a further 2 platforms roosting / resting on ledges of an appropriate size which could potentially support breeding birds. Most occupied platforms occurred in sector 48 and 49, with highest numbers found close to the Flamborough frontal region (see **Table A 4**).

4.1.2.2 A few occupied platforms (supporting populations of up to 260 breeding pairs) were found within this region which overlapped some of the core foraging areas (based GPS tracking data, i.e. 50% utilisation distribution) from birds breeding at FFC SPA, primarily in the more distant South Eastern hotspot (approximately 100 km) from FFC SPA (Cleasby et al. 2018, See **Figure A 6**). However, only small numbers of nests were found on platforms within the core foraging area closest to FFC SPA (see **Figure A 6**) and the most heavily populated platforms occurred outside these known core foraging areas. **Figure A 6** shows the survey results plotted against mean foraging range (55 km radius) of known kittiwake colonies along the North Sea coast of the UK (and northern Europe), most occupied platforms in the SNS occur beyond the mean foraging range of known kittiwake colonies (though these sectors are where most of the survey effort was also focused – **Table A 4**).

4.2 Numbers of breeding kittiwake.

Table A 4: Areas covered and preliminary results from June 2021 offshore surveys.

Location – OGA Block	Total N. installations in block	N. installations surveyed	% area covered	Breeding confirmed	Present but not breeding	Absent (apparently absent[7])
42	9	2	22%		1	1 (1)
43	5	3	60%		1	2
44	15	0	0%			
47	12	1	8%	1		
48	41	7	17%	5		1 (1)
49	75	7	9%	2		3 (2)

4.2.1.1 Results from individual platforms detailing the number of breeding pairs, trace nests and apparently occupied sites (which could potentially represent young birds recently recruiting into the colony), along with additional behaviours and other species seen are shown in **Table A 5** and **Table A 6**. A notable observation was that guillemots and Razorbill were

[7] Numbers indicate the number of installations where kittiwakes were found to be present or absent in each location, installations which were not fully surveyed but which were not thought to have breeding birds on passing were recorded as ' apparently absent'.

recorded on ledges on one installation in sector 48 and could potentially be breeding.

Figure A 4: Potential nesting Guillemots (above) and possible Razorbill sites (below)on a platform within sector 48.

Table A 5: Results of June kittiwake population census counts at offshore installations in the southern North Sea.

Platform ID	Location - block	Number of breeding pairs (AONs)	Trace nests	Apparently occupied sites	% colony visible	Est. hidden nests (if applicable)	Min survey distance (m)	Confidence, 1= good, 2= adequate, 3 = poor
UKSNS01	47	1	0	1	99	0	500	1
UKSNS02	43	0	0	2 potential.	99	0	100	1
UKSNS03	42	0	0	30 potential.	99	0	100	1
UKSNS04	43	0	0	0	99	0	100	1
UKSNS05	43	0	0	0	99	0	100	1
UKSNS06	49	47	9	0	98	1	100	1
UKSNS07	49	0	0	0	99	0	100	1
UKSNS08	49	409	72	43	95	22	100	1
UKSNS09	49	0	0	0	99	0	100	1
UKSNS10	49	0	0	0	99	0	100	1
UKSNS11 COMPLEX	48	266	43	32	90	30	100	1
UKSNS12	48	260	48	9	98	5	100	1
UKSNS13	48	0	0	0	99	0	100	1
UKSNS14	48	24	21	19	99	0	100	1
UKSNS15	48	25	18	15	98	1	100	1
UKSNS16	48	362	43	18	85	64	100	1
UKSNS17	42	0	0	0	50	?	>500	2
UKSNS18	49	0	0	0	50	?	>500	2
UKSNS19	49	0	0	0	50	?	>500	2
UKSNS20	48	0	0	0	50	?	>500	2

Table A 6: Additional counts of kittiwake and information on other seabird species recorded during June seabird census surveys. Breeding confirmed column: Y-yes, P-present not breeding, A-absent, AA-apparently absent.

BLK	Platform ID	Breeding confirmed.	Tot. N. birds attending breeding ledges	N. birds in wider area i.e. not on breeding ledges	N. 1CY birds	Other species breeding?	NOTES e.g. Bird deterrents, behaviour, structural notes	other species present
47	UKSNS01	Y	4	57 on structure, +60 in flight	10+	None apparent		Great black-backed gull, Herring gull and lesser black-backed gull present on structure (no evidence of breeding)
43	UKSNS02	P	0	4 on structure 1 flying West	0	None apparent		Great black-backed gull, Herring gull and lesser black-backed gull present on structure (no evidence of breeding)
42	UKSNS03	P	48	33 on structure, 38 in flight	Present	None apparent	birds mainly on NE and NW sides and on helideck. Feeding flock observed off platform. Same structure as UKSNS05 and UKSNS06	Great black-backed gull, Herring gull and lesser black-backed gull present on structure (no evidence of breeding)
43	UKSNS04	A	0	0	0	None apparent		Great black-backed gull, Herring gull and lesser black-backed gull present on structure (no evidence of breeding)
43	UKSNS05	A	0	0	0	None apparent	Personnel on rig no evidence of any nests - same structure as UKSNS03 and UKSNS06	Great black-backed gull, Herring gull and lesser black-backed gull present on structure (no evidence of breeding)
49	UKSNS06	Y	92	63 on top of helideck	15	None apparent	Mainly under helideck, appears to be space for expansion	Great black-backed gull, Herring gull and lesser black-backed gull present on structure (no evidence of breeding)

BLK	Platform ID	Breeding confirmed.	Tot. N. birds attending breeding ledges	N. birds in wider area i.e. not on breeding ledges	N. 1CY birds	Other species breeding?	NOTES e.g. Bird deterrents, behaviour, structural notes	other species present
49	UKSNS07	A	0	0	0	None apparent		Great black-backed gull, Herring gull and lesser black-backed gull present on structure (no evidence of breeding)
49	UKSNS08	Y	578	TBC from photos	TBC from photos	None apparent	Heavily populated most available ledges occupied	Great black-backed gull, Herring gull and Lesser black-backed gull present on structure (no evidence of breeding)
49	UKSNS09	A	0	0	0	None apparent		Great black-backed gull, Herring gull and lesser black-backed gull present on structure (no evidence of breeding)
49	UKSNS10	A	0	0	0	None apparent		Great black-backed gull, Herring gull and lesser black-backed gull present on structure (no evidence of breeding)
48	UKSNS11 COMPLEX	Y	381	TBC from photos	TBC from photos	None apparent	Large complex of 5 platforms attached including manned accommodation unit	Great black-backed gull, Herring gull and lesser black-backed gull present on structure (no evidence of breeding)
48	UKSNS12	Y	298	27 on top of Helideck on W side, birds present all around helideck.	TBC from photos	Poss. – Guillemot & Razorbill	Feeding flock mix kits, gulls guillimots and razorbill to East of platform c.40 auks at base of platform. Auks on ledges - potentially breeding!	c.100 guillemots on structure ledges – some potentially breeding based on behaviour/ ‘humpback’ posture of birds, with more loafing on lower sections and c. 40 on water below. 13 Razorbill on upper ledges

BLK	Platform ID	Breeding confirmed.	Tot. N. birds attending breeding ledges	N. birds in wider area i.e. not on breeding ledges	N. 1CY birds	Other species breeding?	NOTES e.g. Bird deterrents, behaviour, structural notes	other species present
48	UKSNS13	A	0	0	0	None apparent	collard dove on platform	Great black-backed gull, Herring gull and lesser black-backed gull present on structure (no evidence of breeding)
48	UKSNS14	Y	78	69	23	None apparent	58(6 immatures) counted on structure from N side	Great black-backed gull, Herring gull and lesser black-backed gull present on structure (no evidence of breeding)
48	UKSNS15	Y	70	47 on structure, C.100+ flushed from helideck	11	None apparent		Great black-backed gull, Herring gull and lesser black-backed gull present on structure (no evidence of breeding)
48	UKSNS16	Y	415	110	TBC from photos	None apparent	Majority under lowest level of platform and some on level 2, lack of birds in innermost section of base.	Great black-backed gull, Herring gull and lesser black-backed gull present on structure (no evidence of breeding)
42	UKSNS17	AA	-	-	-	None apparent	Passing observation only - no detailed survey	None apparent no counts made
49	UKSNS18	AA	-	-	-	None apparent	Passing observation only - no detailed survey	None apparent no counts made
49	UKSNS19	AA	-	-	-	None apparent	Passing observation only - no detailed survey	None apparent no counts made
48	UKSNS20	AA	-	-	-	None apparent	Passing observation only - no detailed survey	None apparent no counts made

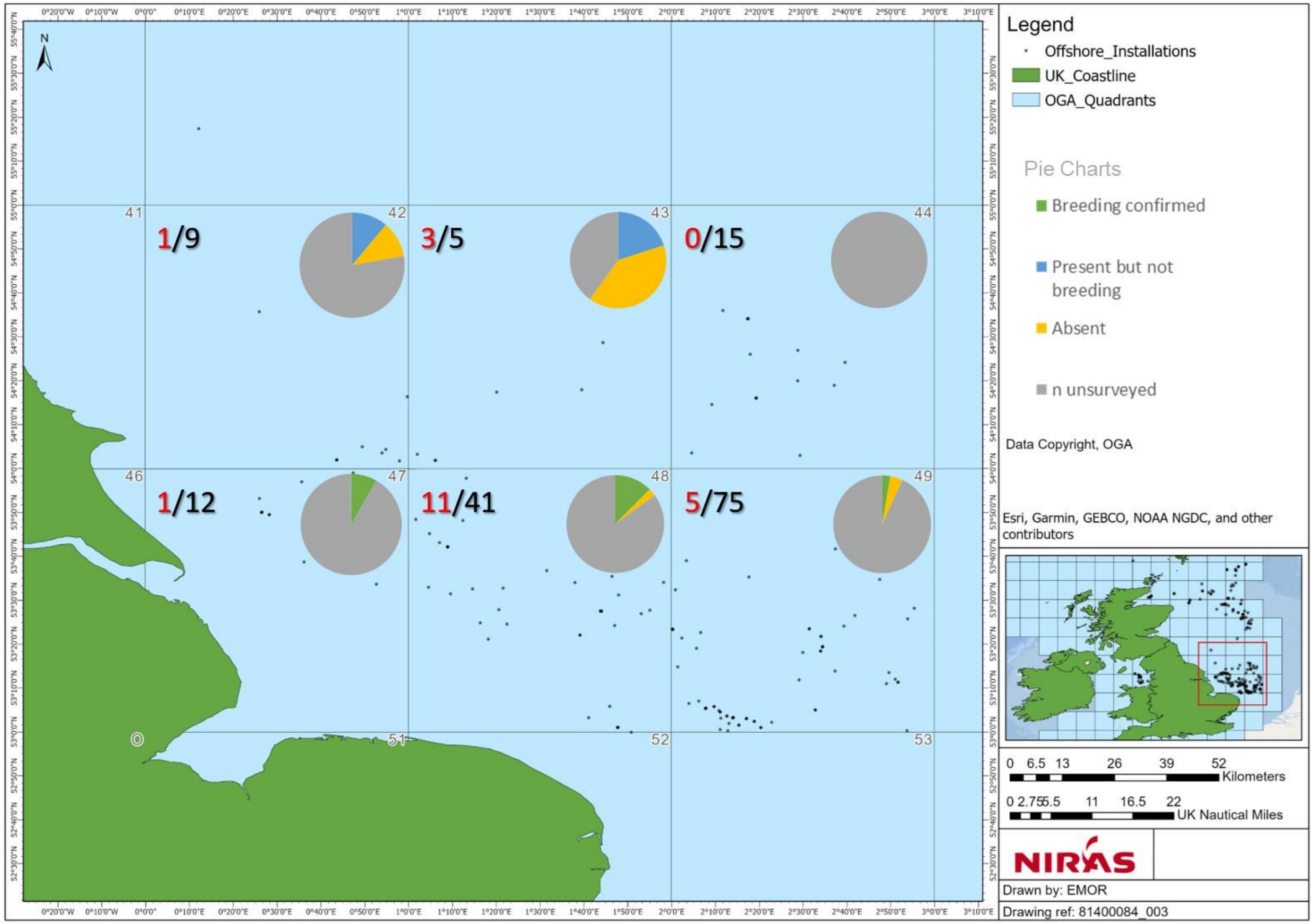

Figure A 5: Survey area shown with respect to OGA blocks highlighting the number of installations surveyed within each sector, shown in red, of the total number, shown in black. Pie charts show the presence of breeding birds at each of the platforms surveyed in June 2021.

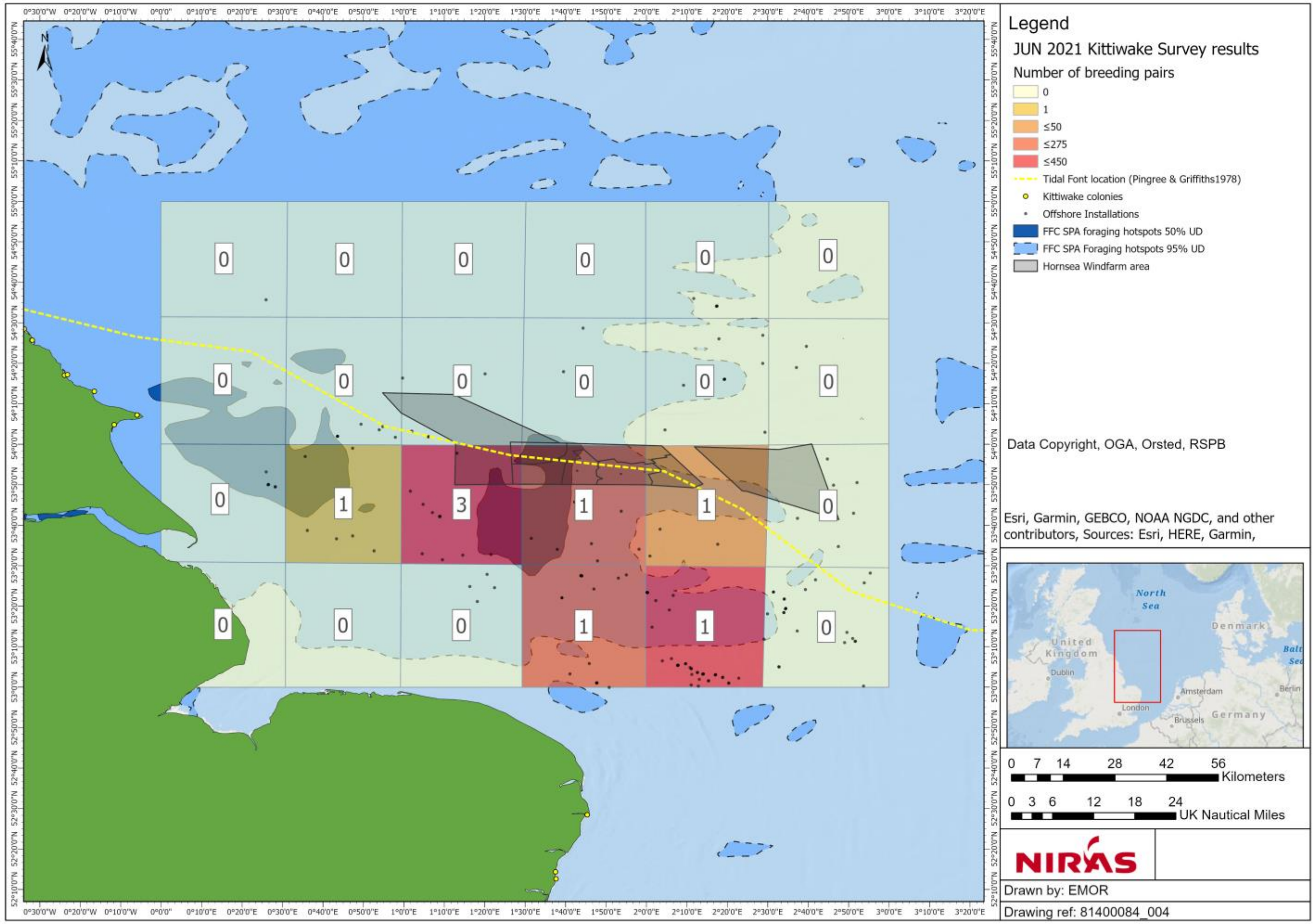

Figure A 6: Number of breeding kittiwake in each OGA block location with the number of platforms surveyed in June 2021 shown in white boxes. Foraging area extent (95% utilisation distribution) and core (50% utilisation distribution) of kittiwakes from FFC SPA, approximate position of tidal front are also shown.

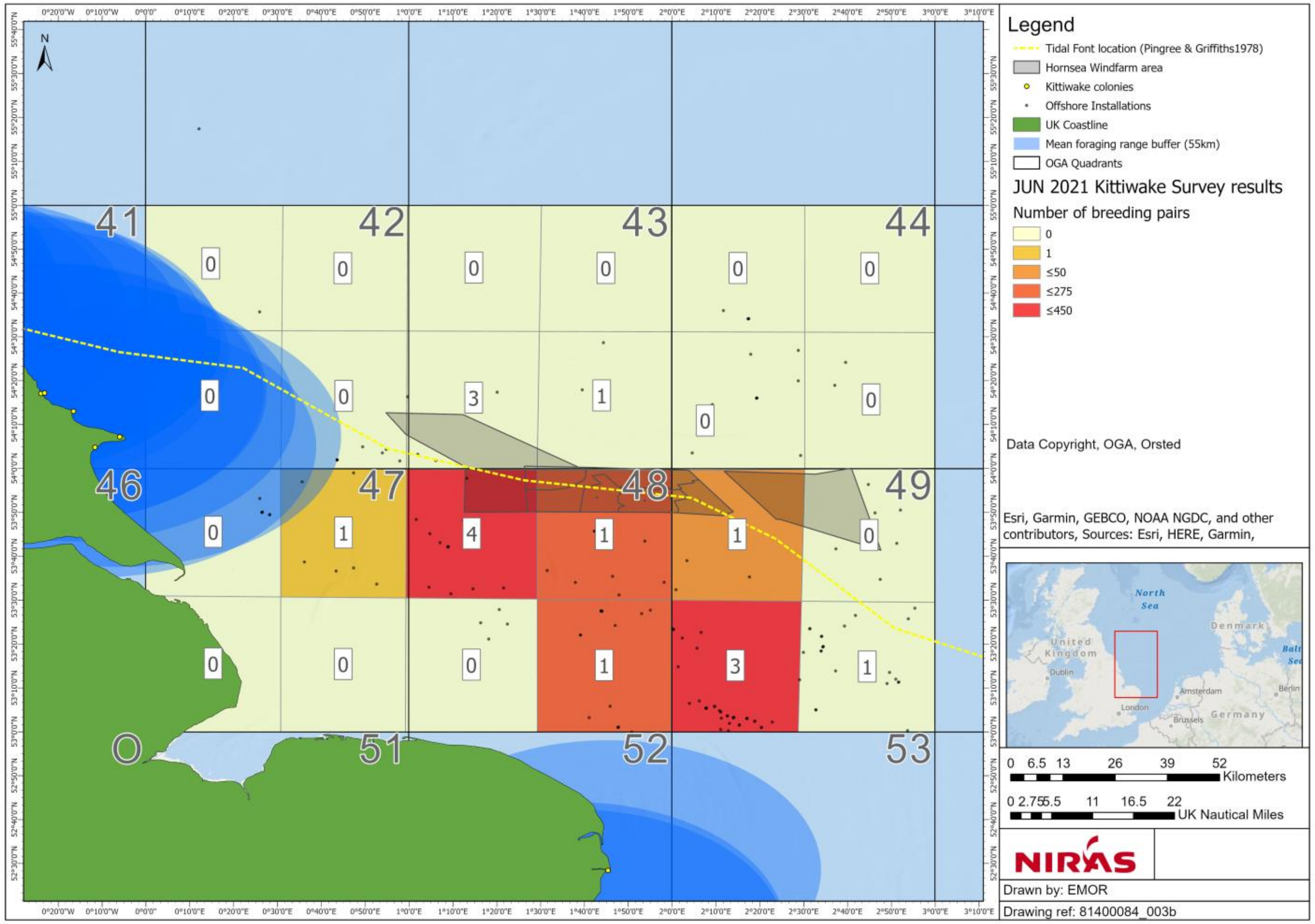

Figure A 7: Number of breeding kittiwake in each OGA block location with the number of platforms surveyed in June 2021 shown in white boxes. Mean foraging ranges of kittiwakes from all known onshore coastal Kittiwake colonies in the UK and approximate position of tidal fronts Foraging areas are also shown.

Table A 7: Summary of Platforms.

Platform ID	Breeding confirmed.	AON	Type	Topside Style	Ledge info	Main nesting locations used	Manned? (freq. if poss.)	Bird deterrents
UKSNS08	Y++	409	Fixed Steel above water production	Tall SSP-OH (3levels- helideck on top of old accom block? approx. 4 containers high)	no I-beams / ledges below helideck, beams present beneath stricture enclosed by side ledges.	Birds nesting mainly on outer faces, particularly I-beans on sides of structure a few beneath ant into internal sections.	Normally unmanned installation (NUI)	unknown
UKSNS16	Y++	362	Fixed Steel above water production	SSP-OH, level 2 longer than 1 so overhangs water	I-beams present and of suitable size primarily under structure at level 1, also under level 2 particularly where overhanging water - gridded pattern so sides are open on N and S faces, only enclosed so outside ledges largely only present on N and E faces. I-beams may be present under helideck but look short and narrow, plus gridded struts towards centre. Fewer birds in very centre of underside.	Birds nesting primarily on I-beams below level 1 of structure.	NUI	unknown
UKSNS11 COMPLEX	Y++	266	Fixed Steel above water production	Large complex mix of irregular and square shapes connected by walkways	I-beams present largely below and along some sides of structures	Primarily on I-beams on Northern sides of PW, PC and PM with some under walkways and beneath platform	YES	Netting in some areas i.e. around cranes.
UKSNS12	Y++	260	Fixed Steel above	LSP-OH	I-beams present and of suitable size all around sides and larger ledges around supports/legs, suitable	Mainly on outer ledges especially eastern sides with	NUI	Yes – some bird spikes (vertical type) noted in

Platform ID	Breeding confirmed.	AON	Type	Topside Style	Ledge info	Main nesting locations used	Manned? (freq. if poss.)	Bird deterrents
			water production		ledges under structure also. under helideck suitable I-beams exist but lots of zig-zag struts between them	a few nesting beneath. guillemots and razorbill also present on ledges.		parts – birds nesting on top of them.
UKSNS11 F	Y++	177	Fixed Steel above water production	satellite to N of site with adjoining walkway to complex	I-beams present largely below and along some sides of structures	As UKSNS11 complex	YES	unknown
UKSNS11 A	Y+	50	Fixed Steel above water production	Two adjoining blocks poss. should be viewed as one at centre of complex	I-beams present largely below and along some sides of structures	As UKSNS11 complex	YES	unknown
UKSNS06	Y+	47	Fixed Steel above water production	SSP-OH	I-beams present and of suitable size all around sides and under helideck, may be suitable ledges under structure also	Birds largely all on I-beams under helideck	NUI	NONE
UKSNS11 C	Y+	36	Fixed Steel	Two adjoining blocks poss.	I-beams present largely below and along some sides of structures	As UKSNS11 complex	YES	unknown

Platform ID	Breeding confirmed.	AON	Type	Topside Style	Ledge info	Main nesting locations used	Manned? (freq. if poss.)	Bird deterrents
			above water production	should be viewed as one at centre of complex				
UKSNS15	Y+	25	Fixed Steel above water production	SSQSP-SQH - small square satellite platform, monopile leg and helideck directly above	I-beams present and of suitable size mainly around lower level sides, no I-beams below helideck but some ledge spaces present, suitable ledges under structure also	Birds primarily on outer edges on N E and W sides	NUI	unknown
UKSNS14	Y+	24	Fixed Steel partially decommissioned	Legs only	only leg struts remain topside has been removed, however upper fixings on each leg have compartments suitable for nesting and are occupied.	Birds nesting in small compartments-ledges on top of each of the 4 legs	NUI	unknown
UKSNS11D	Y	3	Fixed Steel above water production	satellite to SE of site with adjoining walkway to complex	I-beams present largely below and along some sides of structures	A few birds on outer ledges of structure	YES	unknown
UKSNS01	Y	1	Fixed Steel above water	SSP-OH -Small satellite platform 2-3 levels with	I-beams present below structure; sides look very narrow in places but some sections wide enough to support nests but not continuous. Scattered small I-beams under parts of helideck	One nesting on outermost southern ledges, a small number	NUI	NONE

Platform ID	Breeding confirmed.	AON	Type	Topside Style	Ledge info	Main nesting locations used	Manned? (freq. if poss.)	Bird deterrents
			production	octagonal helideck partially overhanging water		sat on ledges close to nesting pair.		
UKSNS02	P	0	Fixed Steel above water production	SSP-OH - larger?	I-beams present in and around most of structure, look very narrow in places but some sites suitable.	A few birds sat on suitable ledges on outside of structure but no nests observed	NUI	YES - stated that Gull Scat is present on helideck
UKSNS03	P	0	Fixed Steel above water production	SSP-OH	I-beams present and of suitable size all around sides and under helideck, may be suitable ledges under structure also	A few birds sat on suitable ledges on outside of structure but no nests observed	NUI	NONE
UKSNS04	A	0	Fixed Steel above water production	SSP-OH plus Jack-up	I-beams present and of suitable size all around sides and under helideck but look heavily rusted, suitable ledges under structure also. Jack up sides have no ledges legs/struts haves some kittiwake sized compartments on.	None present	NUI	YES – stated that Gull Scat is present on helideck
UKSNS05	A	0	Fixed Steel above	SSP-OH	I-beams present and of suitable size all around sides and under helideck, may be suitable ledges under structure also	None present	NUI	NONE

Platform ID	Breeding confirmed.	AON	Type	Topside Style	Ledge info	Main nesting locations used	Manned? (freq. if poss.)	Bird deterrents
			water production					
UKSNS07	A	0	Fixed Steel above water production	Low SSP (1-2 level) w square helideck on level 2, plus bridge linked jack-up modified compression platform?	I-beams (if present) have very narrow ledges, No ledges on base or side of jack-up or on legs	None present	NUI	NONE
UKSNS09	A	0	Fixed Steel above water production	LSP-OH -Larger satellite platform 2-3 levels with octagonal helideck	few I-beams with suitable ledges on sides but some present beneath and elsewhere, a few ledges below helideck.	None present	NUI	NONE
UKSNS10	A	0	Fixed Steel above water production	LSP-OH	few I-beams with suitable ledges on sides but some present beneath and elsewhere, a few ledges below helideck.	None present	NUI	NONE
UKSNS13	A	0	Fixed Steel	SSQSP-OH - small square	I-beams present and of suitable size all around sides and under structure, but majority are fitted with	None present	NUI	YES – horizontal bird spikes on most ledges

Platform ID	Breeding confirmed.	AON	Type	Topside Style	Ledge info	Main nesting locations used	Manned? (freq. if poss.)	Bird deterrents
			above water production	satellite platform, monopile leg and helideck directly above	horizontal bird spikes. No space / beams below helideck.			
UKSNS11 B	A	0	Fixed Steel above water production	Satellite to West with adjoining walkway - accom block and helideck	I-beams present largely below and along some sides of structures	None present	YES	unknown
UKSNS11 E	A (though some on adjoining walkway)	0	Fixed Steel above water production	large rectangular block at centre of complex	I-beams present largely below and along some sides of structures	None present	YES	unknown
UKSNS17	AA	0?	Fixed Steel above water production	SSP – square platform – no Helideck?	Too far for full assessment – one side looks to have shear face with no ledges.	None present – only 1 side visible from distance	unknown	unknown
UKSNS18	AA	0?	Fixed Steel above	SSP-OH	Similar to UKSNS07, I-beams present below. helideck with Criss cross beams below, small I-beams may be present.	None present – only 2 side visible	unknown	unknown

Platform ID	Breeding confirmed.	AON	Type	Topside Style	Ledge info	Main nesting locations used	Manned? (freq. if poss.)	Bird deterrents
			water production			from distance. No birds on helideck		
UKSNS19	AA	0?	Fixed Steel above water production	Two adjoining square platforms	Adjoined low 2-3 level platform with walkway. I-beams look to be present on sides/	None present – only 1 side visible from distance. No birds on helideck.	unknown	unknown
UKSNS20	AA	0?	Fixed Steel above water production	Larger square satellite platform (4-5 levels) with large overhang and crane.	Too far for full assessment – I-beams present below and on sides no sign of nesting birds.	None present – only 1-2 side visible from distance. No birds on helideck.	unknown	unknown

4.3 Features of occupied vs unoccupied installations.

Figure A 8: Examples of nesting kittiwake sites on offshore installations, I-beams below a structure (above) and I-beams below a helideck (below).

4.3.1.1 Platforms surveyed were largely unmanned fixed steel above water production platforms. All structures surveyed varied in appearance, size shape and colour but most had a similar basic structure consisting of two main levels plus a helideck platform (**Figure A 4**). Birds were mostly found breeding on parts of the structure constructed using I-Beams, these seem to provide favourable ledges for kittiwake nests. Nests were generally located on the side edges and below the lower levels of the structures (see **Figure A 8**), however at some sites birds were nesting beneath level 2 and level 3 (helideck) of the structure. **Table A 11** details features and components of each platform surveyed, images of each structure can be found in **Appendix A 1**.

4.3.1.2 The most common occupied platform design seemed to be variations of a satellite platform with 2-3 levels and an octagonal helideck, with birds particularly occupying sections partially/fully overhanging water. However, the majority of platforms for which permissions could be obtained to carry out surveys were of this style. At one site where the topside had recently been decommissioned, and only the jacket remained, breeding birds were still present on ledges found at the top of the remaining jacket legs.

4.3.1.3 Unoccupied structures also consisted of some platforms which were of very similar designs to occupied platforms, others had a more notable lack of available ledges or in some cases obvious bird deterrents such as bird spikes (**Table A 11**). Information gained from the helideck certification agency (https://www.helidecks.org/) indicated some of the unoccupied platforms were operating GULL SCAT an acoustic bird scaring devices. Bird deterrents were also observed on some occupied platforms, these were netting and spikes located in certain areas of the platform, some of which did not appear to be particularly effective. Further information is being sought on the use of bird deterrents and levels of disturbance (i.e. manned hours/ frequency of helicopter operations) on the platforms surveyed to aid in assessments of why some platforms are unoccupied by kittiwake.

4.3.1.4 On one manned platform complex (UKSNS11) had platforms with and without nesting birds – this provides a good opportunity for comparisons within the same geographic locality. Here birds were not found below the accommodation platform, however, they were found below walkways and in good numbers elsewhere on the platform. On the manned complex the older platforms (constructed in the 1990's) contained a higher number of breeding pairs, than the newer platforms i.e. the accommodation platform (built in 2014), however the occupied sections were located primarily on the eastern side which may be more preferred by birds (see section 4.4 below) side, the older platforms located on the western end of the complex also had no breeding birds.

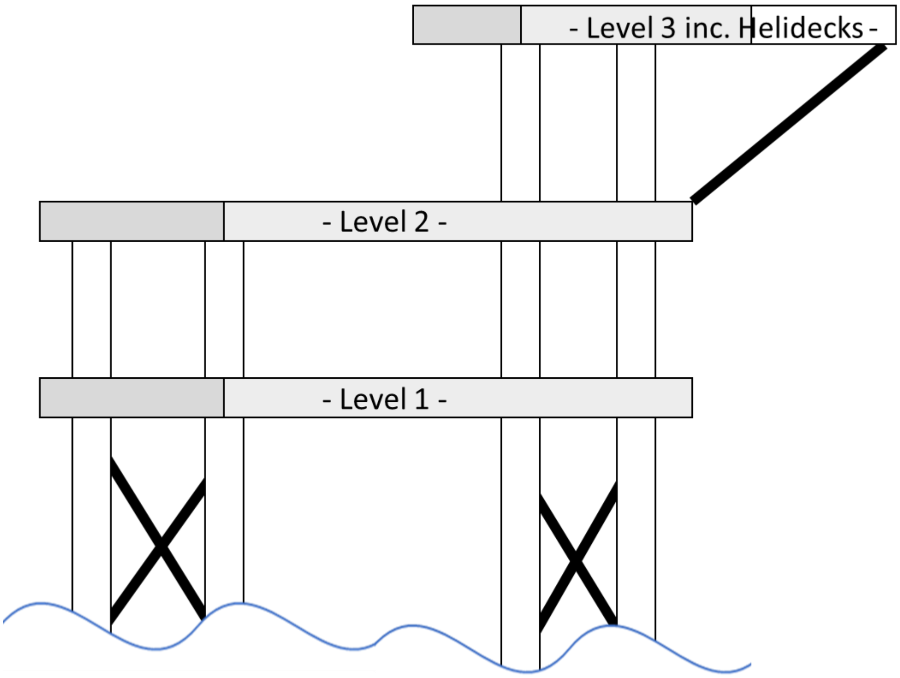

Figure A 9: Schematic showing height levels used in survey.

4.4 Nesting site preferences of birds – within installations Fine scale.

4.4.1.1 Most breeding birds were apparently incubating eggs on nests seen during the June survey. Locations of each nest was mapped and details on its location and aspect they faced was noted. On occupied platforms the distribution may be confounded by the availability of suitable ledges, and potentially by human activities e.g. deterrents/disturbances. Across all occupied platforms examined in this survey, birds showed a preference for lower levels of the platform (Level 1 which is closest to sea level), which was apparent for AONs and traces/AOS (Table A 8). Little difference was observed in the number of birds seen nesting on the outside of platforms (n= 668) compared to beneath or within the inner parts of the structures (n=681). Nesting birds were more numerous on the northern and eastern sides of the installations, this effect appears much stronger where birds were nesting on the outside of structures (see Figure A 10). This preference for eastern sides and avoidance of western facing leges seems to hold true across most individual platforms.

Table A 8: Number of kittiwake nests (AON) and nesting attempts (TR and AOS) on locations within each structure.

	Outer ledges i.e. sides of structure			Inner structure i.e. ledges beneath platforms		
Number of nests at each height	Level 1	Level 2	Level 3 / Helideck	Level 1 i.e. under structure	Level 2	Level 3 / Helideck
AON	420	248	-	505	131	45
Traces	579	319	-	53	35	9
AOS	48	25	-	46	18	-

Table A 9: Number of kittiwake nests (AON) and nesting attempts (TR and AOS) facing each aspect on locations within each structure.

OUTER STRUCTURE								
Aspect facing:	**N**	**NE**	**E**	**SE**	**S**	**SW**	**W**	**NW**
N. AON	46	107	163	107	83	73	55	34
N. Traces	13	19	48	17	10	16	21	13
N. AOS	5	10	17	8	5	6	18	4
INNER STRUCTURE								
Aspect facing:	**N**	**NE**	**E**	**SE**	**S**	**SW**	**W**	**NW**
N. AON	160	103	91	25	92	37	115	58
N. Traces	19	11	19	7	2	6	29	4
N. AOS	6	8	15	5	2	3	13	12

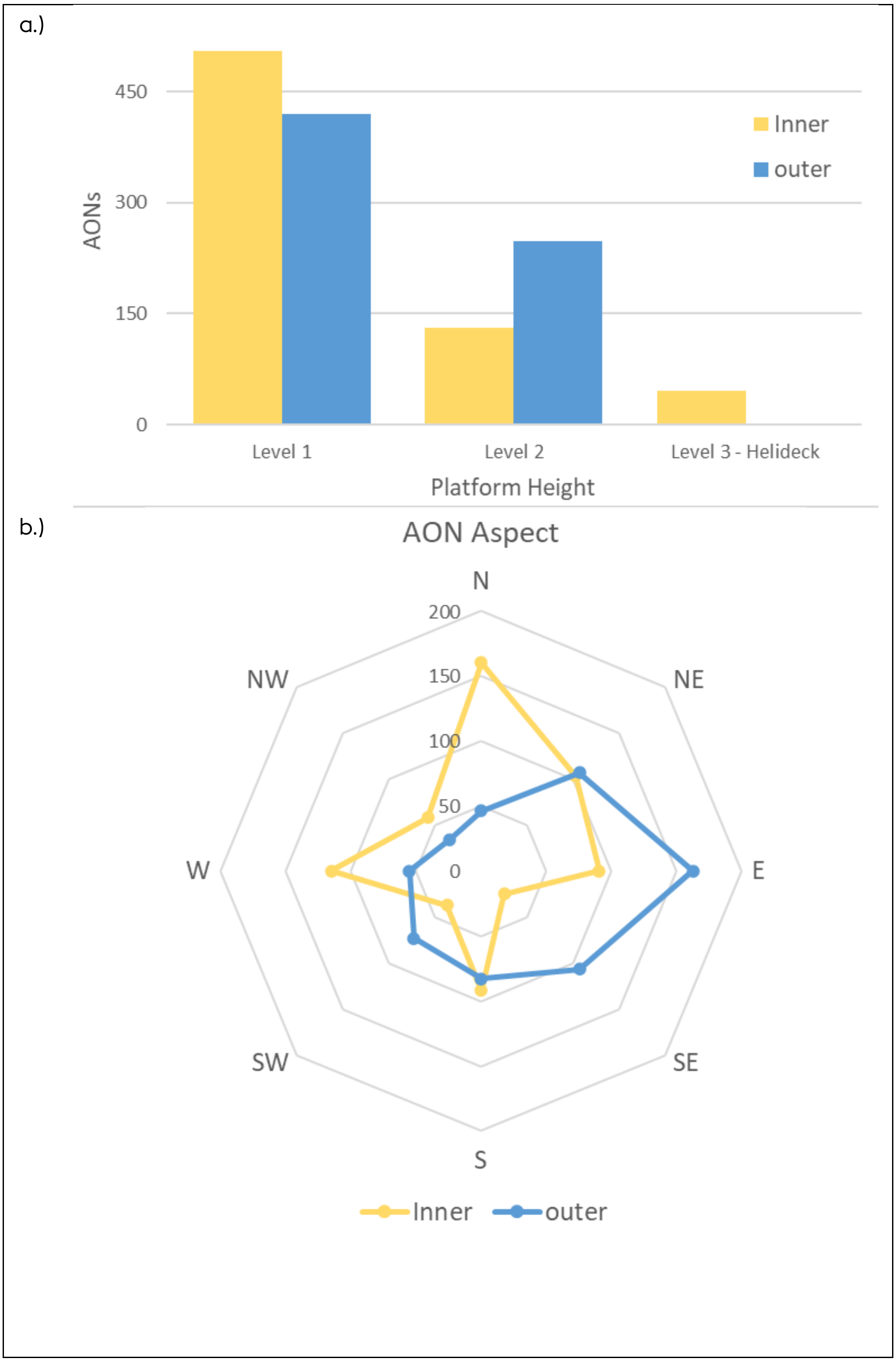

Figure A 10: Information on fine scale location factors of AON on offshore structures; a. Height of platform split by nest location within the inner sections of the structure or the outer sides. b. Aspect each AON was facing within the structure for each platform.

Table A 10: Broad scale features which may influence the presence/ absence or number of nests on occupied platforms.

Platform name:	Breeding confirmed.	AON	Distance from FFC SPA (km)	Water Depth (m)	Within FFC bird foraging area band (% UD*)	Distance from Flamborough Front (km)	YEAR constructed/ production started	Distance to coast (km)
UKSNS08	Y++	409	203.7	40	1	50	1987	59.85
UKSNS16	Y++	362	81.77	32	0.75	25	1993	62.02
UKSNS11 COMPLEX (All)	Y++	266	141.22	23	0.45	51	1990	65.40
UKSNS12	Y++	260	120.88	22	0.2	36	1990	75.71
UKSNS06	Y+	47	168.27	26	1	15	2007	106.15
UKSNS15	Y+	25	92.71	31.7	0.75	21	2001	72.61
UKSNS14	Y+	24	100.06	21	0.8	51	1992	58.61
UKSNS01	Y	1	49.23	40	0.2	25	2003	44.17
UKSNS02	P	0	74.56	45	0.75	0.5	1990	64.17
UKSNS03	P	0	73.57	54	0.9	20	2006	72.17
UKSNS04	A	0	116.55	49	0.85	40	1996	124.43
UKSNS05	A	0	95.63	54	0.8	32	2006	94.20
UKSNS07	A	0	191.06	29	1	17	1989	82.56
UKSNS09	A	0	183.52	40	1	58	1968	57.74
UKSNS10	A	0	182.19	37	1	60	1968	59.19
UKSNS13	A	0	115.31	20	0.4	46	1995	67.61
UKSNS17	AA	0?	70.4	48	0.95	3.5	1989	69.30
UKSNS18	AA	0?	194.22	30	0.9	25	1971	90.96
UKSNS19	AA	0?	188.05	40	1	65	1968	55.00
UKSNS20	AA	0?	147.52	23	0.5	56	2012	65.90

4.5 Nesting site preferences of birds – broad scale i.e. between installations.

4.5.1.1 Environmental factors will also play a role in driving the distribution and favourability of offshore nesting sites to breeding seabirds. The distribution of occupied versus unoccupied sites could provide an insight into the most favourable factors likely to increase colonisation success. Ideally comparisons between occupied and unoccupied structures where design features are present on both that should provide nesting opportunities for kittiwake i.e. adequate ledges and no bird deterrents or regular disturbances would provide the most useful information. There is not enough data on platforms or enough platforms covered to robustly test this from the data collected for this survey, however **Table B 1** provides an indication of some key factors which could influence distributions.

4.5.1.2 Most occupied platforms lie beyond 50 km from FFC SPA (however this may also reflect lower survey effort and the fact that there are fewer installations located in close proximity to FFC SPA), but are all largely within foraging range of the Flamborough front region and known foraging areas of FFC SPA birds.

5 Conclusions/ Summary

5.1.1.1 The results of this survey have increased the knowledge base surrounding offshore nesting kittiwakes in the UK sector of the SNS. In summary:

- Quantitative information on the population size of kittiwake colonies was gained for 16 installations. Breeding was confirmed at 8 installations largely within the sector blocks 48 and 49. A total of 1350 breeding pairs was recorded, with some platforms supporting populations of 200 – 400 pairs each.
- The location and status of nests were mapped at all surveyed installations and photographed for documentation, this will allow further information to be gathered on breeding success in a July survey.
- Nests locations were mapped at a fine scale and the nesting site preferences of birds at occupied installations was assessed with respect to aspect and height. The majority of birds were nesting on I-beams or other narrow ledges, choosing sites largely on the northern to south-east sides of platforms with aspect appearing to be slightly less important for birds nesting beneath structures. The prevailing wind in the area is largely westerly so these areas are likely to offer more shelter. Birds appeared to show little preference between nesting on the outer edges of structures compared to beneath, however it was apparent that more nests were seen below structures on the sections of the platform overhanging the sea. Most sites (due to the shape of the I beam) had a small overhang above the nest.
- Four additional installations were partially examined from outside safety exclusion zones while in transit. All four platforms had no obvious signs of kittiwake presence (i.e. presence of birds in flight around the platform and birds loafing around on helidecks) which were observed at the larger colonies, therefore it is assumed birds were absent from these structures (or at least large colonies are not present).
- 8 installations where birds were absent were found, their features noted and photographs taken. These were then assessed against occupied sites. 3 appear to have bird deterrents, 4 seemed to have narrower I beams and/or more shear faces without ledges than the occupied sites offering fewer nesting spaces, the other sites appeared to offer suitable ledges (one was used as a roost site only). More information is being

obtained on the use of deterrents and regularity of operations of these sites to strengthen the conclusions which can be drawn from this report.

- Few other species were seen breeding on installations, though one site that is likely to have breeding guillemot and razorbill was identified (but could not be fully confirmed, as no chicks or eggs were seen). The majority of platforms had kittiwakes as the sole breeding species. Large gull species (lesser black-backed gull, herring gull and great black-backed gull) were present at most installations where kittiwakes were found but no evidence of breeding was recorded – birds were seen loafing on helidecks or supporting beams and consisted largely of immature birds. Other species seen while on survey include a crow flying from a platform and a collared dove sat on one installation looking particularly bedraggled.

5.1.1.2 The information has increased our understanding of factors influencing the distribution of kittiwake breeding sites in the offshore environment in the following ways which are relevant to the Hornsea Four derogation case:

- In terms of site selection for a new ANS, the area South of the Flamborough front (as depicted by Pingree and Griffiths 1978) but beyond mean max foraging range (55 km) of FFC SPA birds to the north and birds breeding at Lowestoft to the south would be a good candidate. This area is known to support foraging kittiwake from FFC SPA i.e. prey availability is likely to be good, and the existing offshore populations would seem to be coexisting with the FFC SPA population (however data on breeding success is required to support this theory).
- There are platforms in the SNS region with existing populations of breeding kittiwake that are due to be decommissioned in the next few years. Evidence from a structure which was known to previously support a population of breeding kittiwake but had been partially removed by the time of this survey, provides evidence that birds are likely to return to an established site and breed on what remains of the structure, therefore if a new structure was placed nearby birds from a decommissioned site are likely to colonise a new site quickly (evidence from similar situations onshore also supports this – see **B2.7.3 RP Volume B2 Annex 7.3 Compensation measures for FFC SPA Onshore Artificial Nesting Ecological Evidence**).
- To inform future design principals, shelter from prevailing winds and sites overhanging water are important design features, with I-beams providing good nesting sites. Additional information on how fine scale distributions affects productivity is being collected as part of the July survey. This information will inform design features which are likely to enhance breeding success, thus enhancing the chance of the ANS contributing to additionality. In terms of monitoring, creating a structure that meets criteria but could be easily viewed would also be advantageous.

6 References

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Appendix A 1: June Survey Report Platform specific information

Table A 11: Number of kittiwake nests (AON) and nesting attempts (TR and AOS) on locations within each platform based on aspect and location within the structure.

	Row Labels	N	NE	E	SE	S	SW	W	NW	Grand Total
UKSNS12		**40**		**116**		**74**		**30**		**260**
	Inner	27						29		56
	outer	13		116		74		1		204
UKSNS11 A			**50**							**50**
	Inner		50							50
UKSNS11 C			**36**							**36**
	Inner		31							31
	outer		5							5
UKSNS11 D			**3**							**3**
	outer		3							3
UKSNS11 F		**50**		**51**				**76**		**177**
	Inner	39		26				40		105
	outer	11		25				36		72
UKSNS15		**5**		**7**		**1**		**12**		**25**
	Inner					1		3		4
	outer	5		7				9		21
UKSNS16		**111**		**65**		**100**		**43**		**319**
	Inner	94		65		91		43		293
	outer	17				9				26
UKSNS08			**102**		**119**		**97**		**91**	**409**
	Inner		3		12		24		58	97
	outer		99		107		73		33	312
UKSNS01									**1**	**1**
	outer								1	1
UKSNS14				**15**				**9**		**24**
	outer			15				9		24
UKSNS06			**19**		**13**		**13**			**45**
	Inner		19		13		13			45

Appendix A 2: June Survey Report: Images of platforms

Figure A 11: Images of platform 1 – occupied (kittiwake nest locations inset).

Figure A 12: Image of platform 2 – unoccupied by kittiwake.

Figure A 13: Images of platform 3 – roosting only (kittiwake locations inset).

Figure A 14: Images of platform 4 – unoccupied by kittiwake.

Figure A 15: Images of platform 5 - unoccupied by kittiwake.

Figure A 16: Images of platform 6 – occupied.

Figure A 17: Image of platform 7 – Unoccupied by kittiwake.

Figure A 18: Image of platform 8 - occupied.

Figure A 19: Images of platforms 9 and 10 – both occupied.

Figure A 20: I mage of platform 11 – complex – some platforms occupied (e.g. left hand modules) some unoccupied (e.g. right hand module).

Figure A 21: Additional images for platform 11 – occupied.

Figure A 22: Images of platform 12 – occupied by kittiwake and auks.

Figure A 23: More images of birds occupying platform 12.

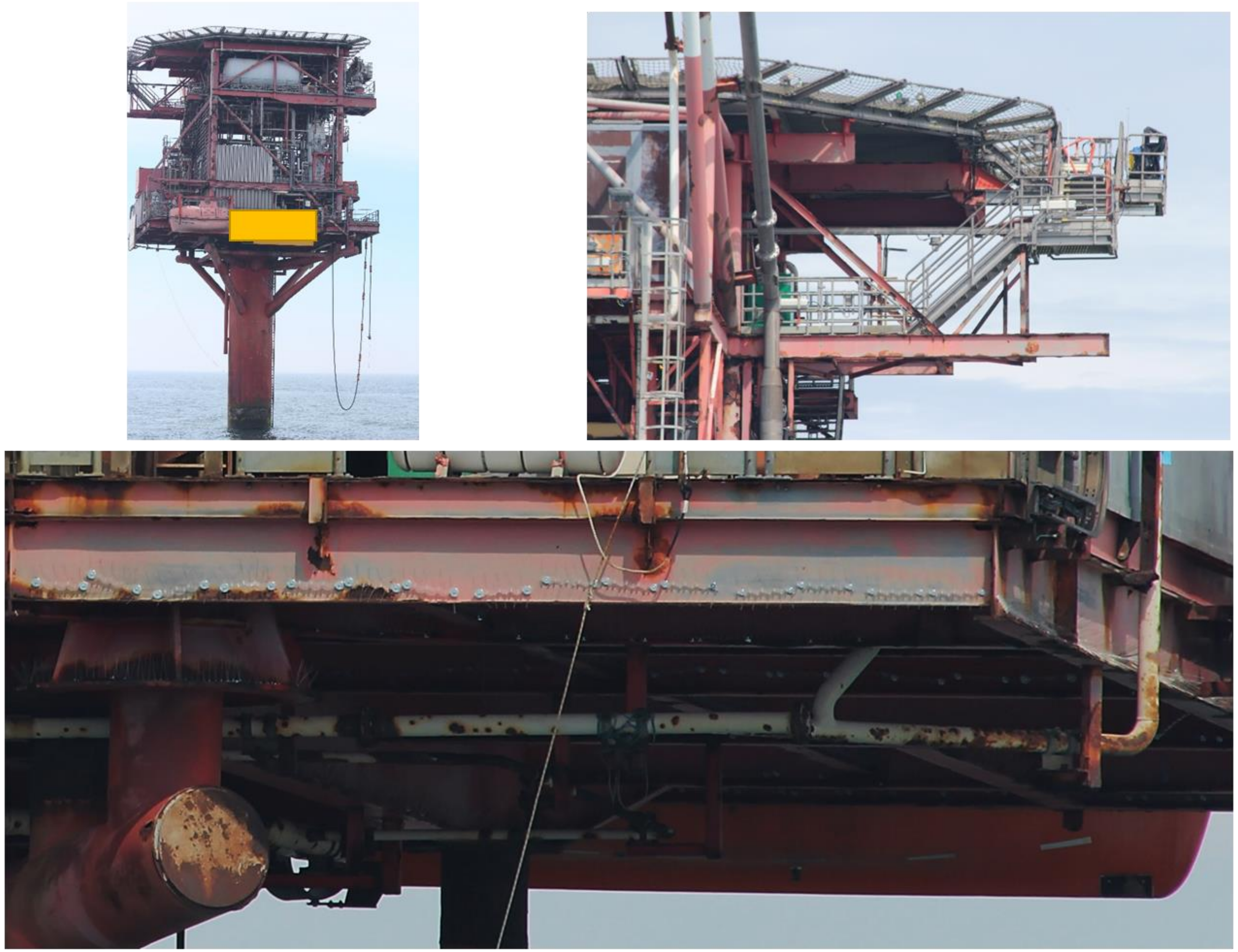

Figure A 24: Images of platform 13 – unoccupied, below image shows horizontal bird spikes.

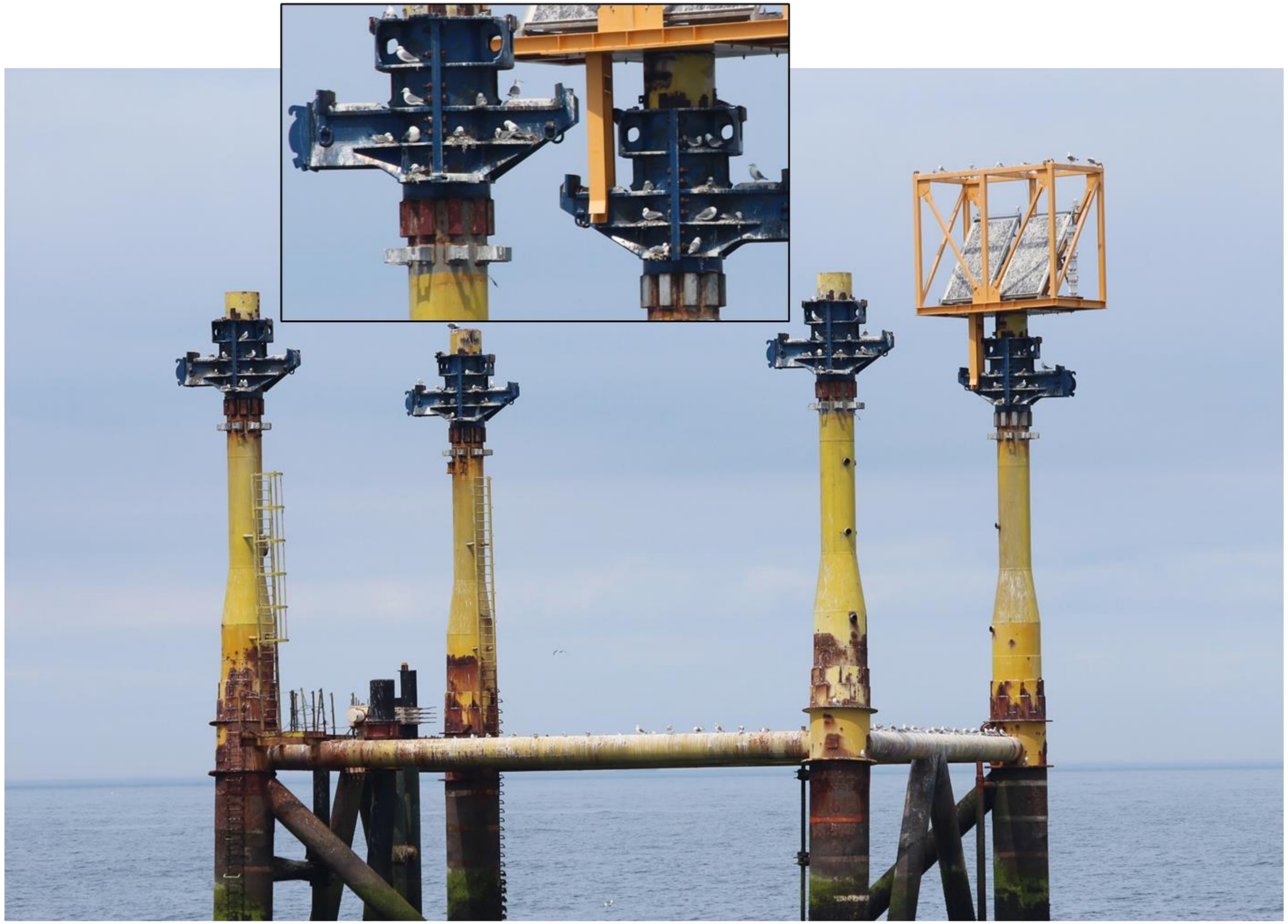

Figure A 25: Images of platform 14 - occupied.

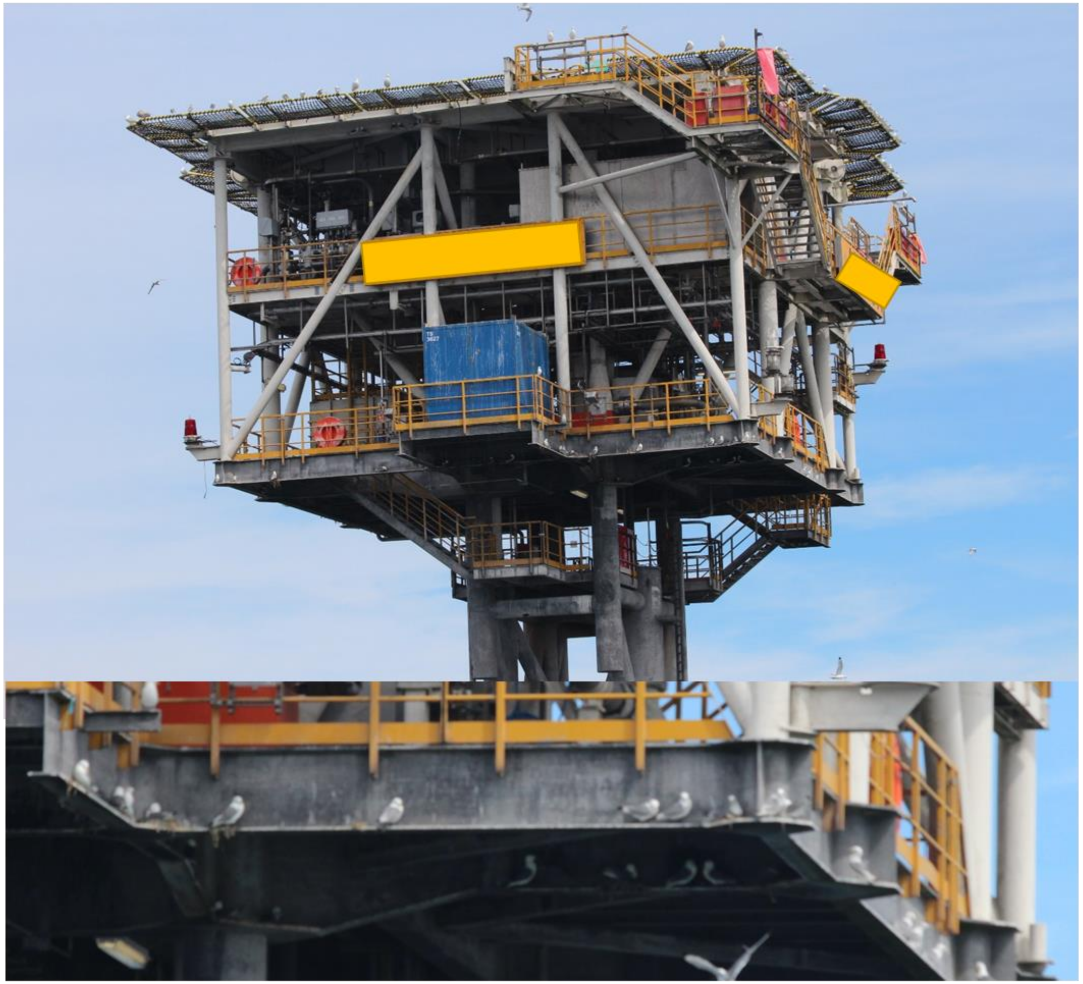

Figure A 26: Images of platform 15 - occupied.

Figure A 27: Image of platform 16 - occupied.

Figure A 28: Images of platform 17-21 - apparently absent (un-surveyed platforms).

Appendix B

Survey Report from the July Boat Based Survey of nesting birds of oil and gas platforms in the southern North Sea

1 Introduction

1.1.1.1 There is now a strong focus on possible compensatory measures for certain designated features of European Marine Sites, which may be required to progress development of offshore wind applications under the Development Consent Order (DCO) process where adverse effects on site integrity (AEOI) cannot be ruled out by Habitats Regulations Assessment (HRA). This follows recent cases such as Hornsea Three where work is ongoing to develop measures to provide compensation for kittiwake Rissa tridactyla populations predicted to be affected by loss of individuals to collision with turbines. The Secretary of State, in making recent judgements, has made clear that exploration of options for compensatory measures must be undertaken in parallel with DCO applications and wider impact assessment/HRA activities.

1.1.1.2 Following identification of the requirement for compensatory measures in relation to the Hornsea Three Offshore Wind Farm and Flamborough & Filey Coast Special Protection Area (FFCSPA), for which NIRAS are currently developing options to provide onshore nesting sites for kittiwake, Orsted is investigating potential compensation options for Hornsea Project Four Offshore Wind Farm (hereafter "Hornsea Four") including the provision of artificial nest sites to produce additional breeding birds to increase the annual recruitment of kittiwake into the regional population of the southern North Sea, which forms part of the wider Eastern Atlantic kittiwake population.

1.1.1.3 To support the proposed derogation measures more information on the nesting habitat and use of offshore structures by kittiwake and other seabirds within the southern North Sea (SNS) is required. This evidence will help inform whether the provision of additional nesting sites, either through the construction of new Artificial Nesting Sites (ANS) or acquisition and modification of an existing structure.

1.1.1.4 Vessel based bird surveys were undertaken in June 2021 around a number of offshore installations in the SNS region to help inform these derogation measures. Sixteen installations were surveyed around the Hornsea project areas and 8 of these installations were found to have breeding kittiwake present (see boast based survey report 1: **Appendix A** to **B2.7.1 RP Volume B2 Annex 7. 1 Compensation measures for FFC SPA Offshore Artificial Nesting Ecological Evidence**). During the consultation processes stakeholders recommended a follow up survey to assess breeding success offshore sites would be beneficial to the derogation case.

1.1.1.5 The primary aim of the survey work was to re-visit installations where kittiwake nesting was confirmed to acquire information on breeding success. A secondary aim was to obtain more information on kittiwake presence at additional Oil and Gas (O&G) installations relevant to Hornsea Project Four area. The study had the following objectives;

- To establish breeding success by recording the status of each nest mapped during June surveys, noting the size and age of any chicks present;
- Record additional nests and photograph each installation again for documentation;
- Document information on the breeding success of birds at occupied installations with respect to aspect, location;
- Add to Orsted's' presence/ absence database by assessing other installations (where survey agreements have not been pursued) for breeding birds from outside safety exclusion zones while in transit; and

- Note the presence of other species of seabird breeding / using platforms.

1.1.1.6 Unfortunately, two of the larger kittiwake breeding colonies (200+ pairs) could not be revisited due to O&G operations preventing access to the areas surrounding these installations during the time of surveying. Therefore, six occupied installations where breeding has been confirmed were resurveyed, along with one platform where large numbers of birds had been seen roosting in June. Unoccupied installations recorded in June were not revisited.

1.1.1.7 The information gathered is intended to support the case for offshore artificial nesting sites as a derogation measure for Hornsea Four in relation to impacts on the kittiwake feature of the FFC SPA. The information gained will be assessed in relation to enhancing our understanding of factors influencing the distribution of kittiwake breeding sites in the offshore environment to inform future site selection processes and design principals.

1.1.1.8 Due to the nature of the agreements between Orsted and the O&G operators the platform identities and owners must remain anonymous and as such a numbering system has been assigned to them for the purpose of this report.

2 Survey Operations

2.1.1.1 Surveys were successfully undertaken at 6 out of 8 proposed installations which were known to have kittiwake breeding (plus one suspected roost site) during a 3 day survey window from 24th July 2021 to 26th July 2021. A detailed breakdown of operations during this period is presented in **Table B 1.** Weather and sea conditions were good throughout the survey period with no survey days lost / postponed due to poor environmental conditions (**Figure B 2**). Sea states were highly favourable for surveys during the survey period, not rising above sea state 3 (see Figure 2.1). Winds ranged from force 1 – 3 NE to NW with light SW winds on the final day of surveys. Visibility was excellent - good for most surveys with some fog recorded on the morning of the 25th July resulting in moderate visibility but this did not affect the survey results as the platform and birds were still clearly visible.

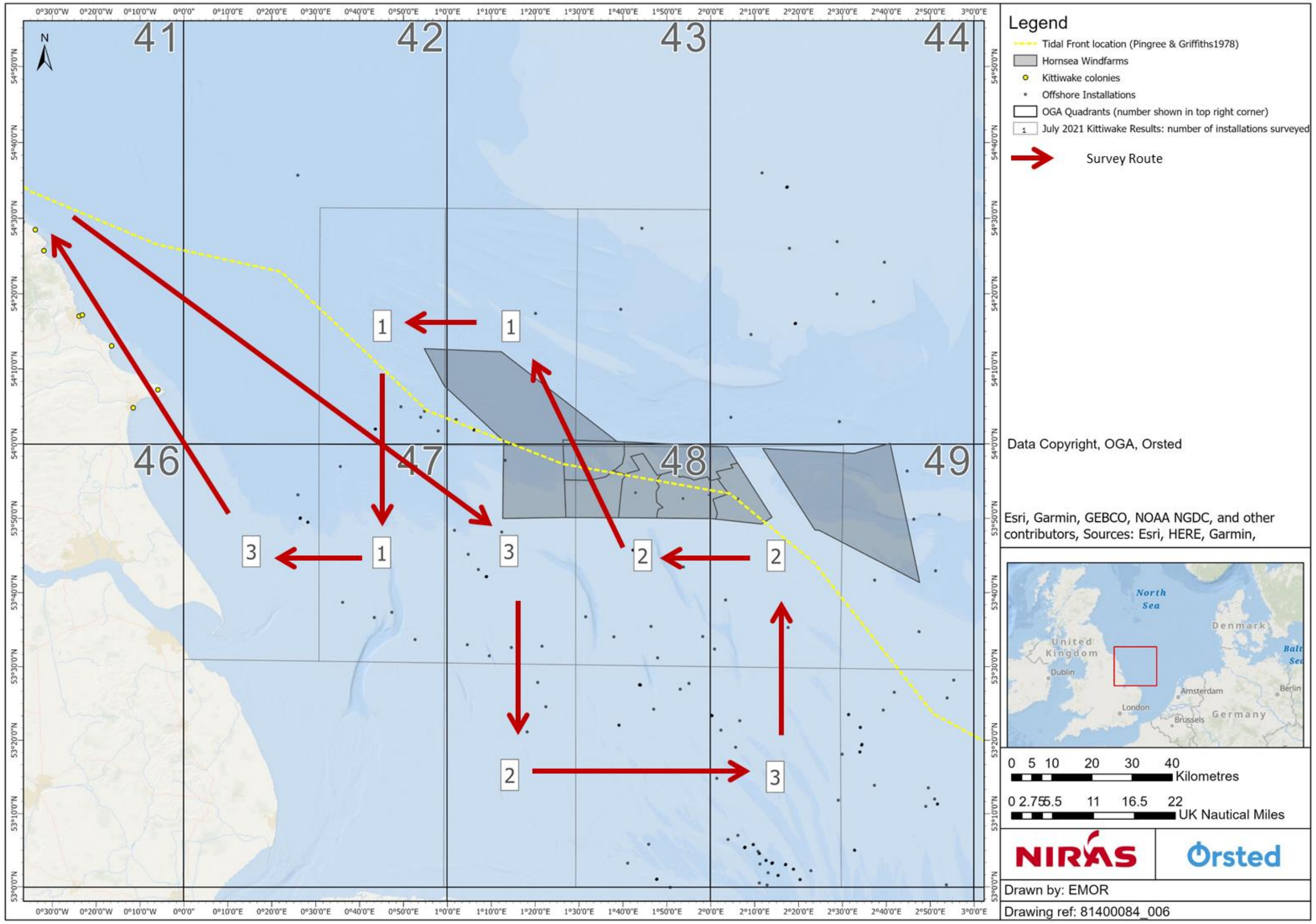

Figure B 1: July survey route showing number and spread of installations surveyed for both targeted installations and opportunistic sites examined on passage (white boxes) within each official OGA quadrant.

Table B 1: Summary of survey operations 24th – 26th July 2021.

Summary of operations: HOW04 Offshore Seabird Census Survey 2

Vessel: DSV Curtis Marshall *Survey Location: Offshore - North Sea*

Date	TIMES (BST)		DIARY OF OPERATIONS	notes
	From	To		
24/07/2021	00:00	05:00	Mobilisation inductions and safety drills (from 5pm 23rd July) - Resting	
	05:00	15:00	Transit to installation 1	
	15:00	20:30	Survey platform 1 (inc. dinner break) completed (within 500 m).	
	20:30	11:59	Standing off in area	
25/07/2021	00:00	05:30	Resting (holding off around installation 2)	
	05:30	06:40	Survey of installation 2 completed (within 500 m).	
	06:41	08:00	Transit to installation 3, TBT and H&S talks	
	08:01	08:40	Standing off in area	
	08:41	13:30	Transit to installation 4 - Issues with gaining access to installation UKSNS12 as planned due to ongoing works	
	13:31	17:15	Survey of installation 4 completed (within 500 m).	
	17:15	11:59	Transit to installation 5 overnight photographing additional installations from beyond 500 m en-route	
26/07/2021	00:00	06:00	Resting (Transit to installation)	
	06:00	06:30	TBT and preparation for entering installations	
	06:30	07:30	Survey installation 5 (within 500 m)	
	07:30	08:20	Transit towards installation 6, with opportunistic surveys beyond 500 m zones en route	
	08:20	08:30	Survey beyond 500 m zone – additional installation 1	
	08:30	09:20	Transit towards installation 6, with opportunistic surveys beyond 500 m zones en route	
	09:20	09:30	Survey beyond 500 m zone – additional installation 2	
	09:30	10:15	Transit towards installation 6, with opportunistic surveys beyond 500 m zones en route	
	10:15	10:25	Survey beyond 500 m zone – additional installation 3	
	10:25	12:20	Transit towards installation 6, with opportunistic surveys beyond 500m zones en route	
	12:20	12:40	Survey beyond 500 m zone - additional installation 4	
	12:40	14:20	Transit towards installation 6, with opportunistic surveys beyond 500 m zones en route	
	14:20	14:45	Survey installation 6 (within 500 m)	
	14:45	17:10	Transit towards installation 7, with opportunistic surveys beyond 500 m zones en route	
	17:11	17:25	Survey installation 7 (within 500 m)	
	17:25	18:00	Transit towards coast, with opportunistic surveys beyond 500 m en route	
	18:00	18:25	Survey beyond 500 m zone- additional installation 5 & 6	

Summary of operations: HOW04 Offshore Seabird Census Survey 2				
Vessel: DSV Curtis Marshall			*Survey Location: Offshore - North Sea*	
Date	TIMES (BST)		DIARY OF OPERATIONS	notes
	From	*To*		
	18:25	18:40	Transit towards coast, with opportunistic surveys beyond 500 m en route	
	18:40	18:50	Survey beyond 500 m zone - additional installation 7	
	18:50	11:59	Transit to port at Hartlepool overnight	
27/07/2021	00:00	06:00	Arrive at Port - Hartlepool & demobilisation	

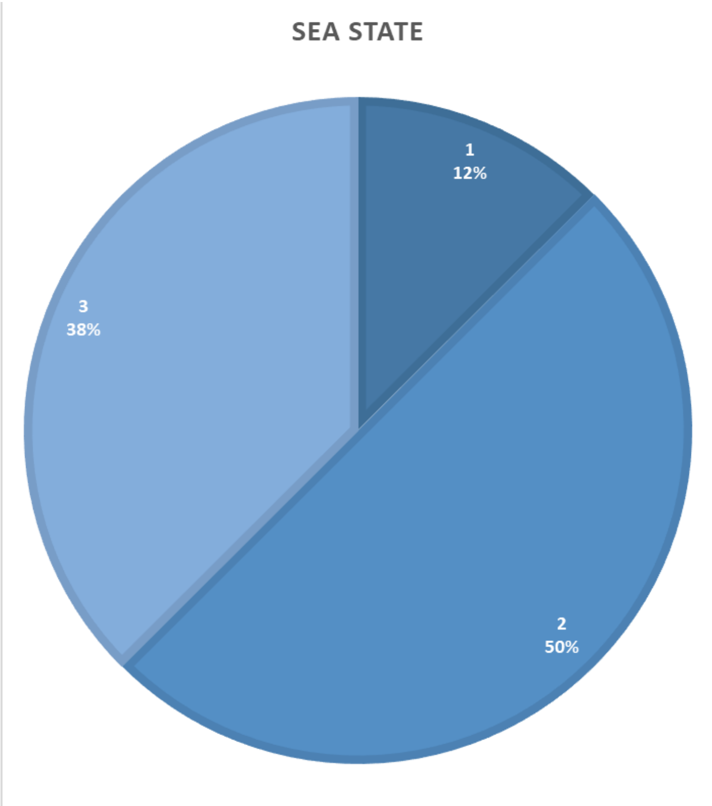

Figure B 2: Summary of sea sate conditions experienced during survey 2

Table B 2: Environmental conditions during survey period

Date	Daylight	Time period	Observed weather conditions on site	Surveying Yes/No
24/07/2021	*Sunrise*:	00:01 - 06:00	Wind NE 9-10 knots, cloudy, temp: 15 degrees.	No
	04:44	06:01 - 12:00	Wind NE 13 knots, cloudy, temp: 16 degrees.	No
	Sunset:	12:01 - 18:00	Wind NE 18 knots, cloudy, temp: 12 degrees. sea state 3	Yes

Date	Daylight	Time period	Observed weather conditions on site	Surveying Yes/No
	21:17	18:01 - 00:00	Wind NE 9-10 knots, cloudy, temp: 11 degrees.	Yes
25/07/2021	Sunrise:	00:01 - 06:00	Wind NE 9-10 knots, cloudy, temp: 16 degrees. sea state 3	No
	04:44	06:01 - 12:00	Wind NE 18 knots, cloudy- fog patches, temp: 16 degrees.	Yes
	Sunset:	12:01 - 18:00	Wind NE 11 knots, sunny, temp: 16 degrees. sea state 1	Yes
	21:18	18:01 - 00:00	Wind N 10 knots, cloudy, 17 degrees. Sea state 1	Yes
26/07/2021	sunrise:	00:01 - 06:00	Wind N-NW 10 knots, Sea state 1	No
	04:44	06:01 - 12:00	Wind NW 10 knots, Sunny, temp: 16 degrees, sea state 2	Yes
	Sunset:	12:01 - 18:00	Wind SW 2-3 knots, Sunny, temp: 16 degrees, sea state 1	Yes
	21:19	18:01 - 00:00	Wind SW-SSE 7 knots, temp: 16 degrees, sea state 2	Yes

2.2 Issues / Incidents

2.2.1.1 There were no issues experienced in obtaining permits to enter within the 500 m exclusion zones of installations on this survey. Weather (wind) and tide conditions on day 1 prevented close access to one platform due to drift on issues which meant the vessel could not hold off as close to the platform as it had done in survey 1 – this meant some nests visible on survey 1 were not fully visible during survey 2, and productivity for these areas could not be assessed. Access could not be granted to the installations UKSNS11 and UKSNS12 due to O&G operational works during the survey period.

3 Survey Methodology

3.1.1.1 Surveys were undertaken between the 24th – 26th July 2021 using methodologies in line with current JNCC and OPRED guidance (JNCC 2021[8] and Walsh et al. 1995[9]).

3.1.1.2 The surveys were carried out using the mapped nests methodology as stated by Walsh et al. (1995). The status of each nest mapped onto diagrams of the installations during the June surveys was reassessed and its contents noted. Nest status was coded following that of Walsh et al. (1995) which included recording the age of chicks, if present. The number of apparently occupied nests AONs (i.e. those capable of holding eggs or with visible chicks) were recorded along with incomplete ("Trace") nests and also individual birds (IND[10]) without an AON or Trace nest occupying a suitable breeding ledge and not identifiably associated from behaviour to be associated with an AON. In addition, the number of adults

[8] JNCC (2021) Advice Note. Seabird Survey Methods for Offshore Installations: Black-legged kittiwakes.
[9] Walsh, P.M., Halley, D.J., Harris, M.P., del Nevo, A., Sim, I.M.W., & Tasker, M.L. (1995). Seabird monitoring handbook for Britain and Ireland.
[10] These IND sites were *termed previously in first survey report as Apparently Occupied Sits (AOS)*

present at each nest was noted. Counts of kittiwakes present but not breeding on and around the structure (including birds on the sea/in flight, those sat on railings and on top of helidecks) were also recorded, as were the number of birds recognisable as immature because of being in 1st calendar year plumage (older immatures are only distinguishable on plumage in the hand) and any fledged juveniles.

3.1.1.3 The location of all visible nests were photographed at each site, as in the first survey visit. The vessel moved slowly around each installation at a distance of 100-500 m, and where required, the vessel held off at certain positions to allow surveyors time to observe and record at each face of the installation. Surveyors aimed to view the section of the installation being surveyed from directly opposite each side, with different vantage points on the vessel used to achieve an optimum viewing position. As per operator H&S requirements, vessels were not permitted to hold off where the vessel could potentially be at risk of drifting onto the platform. The conditions were assessed prior to entering the 500 m exclusion zones. For 'drift on' faces, the vessel held off at the best angle possible for viewing the side from a drift off position and a single pass was made >250 m from the platform to allow for improved visibility of the section if required (see Survey report 1 (**Appendix A to B2.7.1 RP Volume B2 Annex 7. 1 Compensation measures for FFC SPA Offshore Artificial Nesting Ecological Evidence)** for details).

3.1.1.4 Surveys were largely conducted from the upper deck of the vessel using binoculars (specification 10 x 42). Images were taken using a DSLR camera with 70-300 mm image stabilised lens. Where the sea state and weather conditions allowed, a telescope (30-70x zoom, 95 mm objective lens) was used to aid the assessment of nest status. A first pass was generally made at each installation at a 500 m radius to assess the site and photograph each side of the installation prior to entering the exclusion zones.

3.1.1.5 The time taken to survey installations varied with the size, structure and number of platforms at each installation, number of birds present, the location of nests on structures, weather conditions (see **Table B 3** below).

3.1.2 Productivity calculations

3.1.2.1 All large and medium chicks recorded on the July surveys would be expected to fledge, along with 50% of small chicks if fewer than 20% of broods are still small and downy on the last survey date (Walsh et al. 1995). A separate record was kept of the number of small young at each installation and the percentage of small chicks was lower than 20% in all cases (see **Table B 4**). A fledging rate of 50% was therefore assumed for the small chicks recorded in July. Due to the time constraints of surveying offshore, there were occasions where contents of nests where birds were apparently incubating/brooding chicks (e.g. nesting code I, C/x) could not be established. This was the case for 26 nests that were noted across all installations and were removed from the productivity analyses; it is likely that some of these birds were sitting on late broods so the number of small chicks may be higher than stated.

3.1.2.2 Breeding success for each installation was calculated by dividing the number of chicks greater than a size medium (plus half the number of small chicks present) by the total number of nests recorded at positions where sufficient visibility allowed determination of the presence of a nest and assessment of its contents on both visits (see **Table B 5** for breakdown). The total number of nests recorded included all nests which were mapped as incubating (AONs) in June plus nests which were recorded as traces (TR) or individuals on site (IND) on visit one at which subsequent eggs or chicks were recorded on visit two (see **Table B 6).** Productivity was also calculated to allow a comparative analysis of breeding success between locations with different physical characteristics on each of the installations e.g. underneath or on the side of the structure and nest facing aspect.

Table B 3: Survey duration and weather conditions during the surveys at each installation in 2021.

Date	Platform ID	Survey start time	Survey duration (hours)	Kittiwake colony size (AON June)	Sea state	Swell	Wind	Visibility	Cloud cover	Rain	Sun
24 July	UKSNS16	15:15	05:15	362	3	low	2 NE	Excellent	7/8	1	Weak
25 July	UKSNS15	05:30	01:08	25	3	low	3 NE	Good	8/8	1	Weak
25 July	UKSNS14	08:00	00:34	24	2	low	3 NE	Good	8/8	1	Weak
25 July	UKSNS08	13:55	03:20	409	1	low	3 NE	Mod	4/8	1	Moderate
26 July	UKSNS06	06:30	01:00	47	2	low	2 NW	Excellent	2/8	1	Strong
26 July	UKSNS03	14:30	00:15	0 (roost only)	1	low	1 SW	Excellent	1/8	1	Strong
26 July	UKSNS01	17:10	00:20	1	2	low	1 SW	Excellent	4/8	1	Strong

4 Results

4.1.1.1 A total of 7 installations were surveyed from all visible angles within the safety exclusion zones (i.e. >500 m). Repeat surveys were completed at 6 out of the 8 installations which were found to have breeding birds on the June surveys. At all those sites, chicks were present and breeding success was calculated. One installation where only roosting kittiwake had been recorded in June was revisited in July, with again no evidence of breeding recorded.

Table B 4: Size distribution of chicks recorded at each installation in July 2021 survey.

	Size of chicks (as stated in Walsh *et al.* 1995)*							
Installation	*F*	*L*	*ML*	*M*	*SM*	*S*	*Grand Total*	*Percentage of small chicks*
UKSNS15	5	17	1			1	24	4.2%
UKSNS16	18	303	3	8		1	333	0.3%
UKSNS08	163	209	25	12	4	12	425	3.8%

	Size of chicks (as stated in Walsh *et al.* 1995)*							
Installation	*F*	*L*	*ML*	*M*	*SM*	*S*	*Grand Total*	*Percentage of small chicks*
UKSNS01				1			1	0%
UKSNS14		5	3	7		3	18	16.7%
UKSNS06	42	22					64	0%

*S - Downy chick, but black tips to upper wing-coverts just visible, SM - Clear grey/black pattern visible on upperside of wing, but still some down on upperwing, and mainly downy elsewhere, ML - No down on upperside of wings, some down elsewhere, L- No down visible, wing tips at least equal to length of tail, F -wing tips 1-2 cm longer than tail or longer i.e. 3-4 cm longer than tail. Note 'Fledgable' and Fully fledged as defined in Walsh et al. (1995) FF and F codes, were grouped due to difficulties in assessing exact lengths of wing tips from a moving vessel with binoculars.

Table B 5: Number of apparently occupied nests recorded at each installation by each of the two survey visits in 2021 (brackets show number of active nests where contents were able to be assessed) that were adequately visible to be included in productivity monitoring.

Installation	AON JUNE (number suitable for productivity)	AON JULY (number visible for productivity)	Percentage of nests where status could be assessed in July
UKSNS15	25	30 (28)	93%
UKSNS16	362 (323)	381 (296)	78%
UKSNS08	415	451 (437)	97%
UKSNS01	1	1 (1)	100%
UKSNS14	24	30 (26)	87%
UKSNS06	47	60 (57)	95%

Table B 6: Nest status change between visit 1 and 2 for all installations combined in 2021.

		Visit 1 status:					
		Individual (IND)		*Trace **		*Nest (AON)*	
		n.	status classification	n.	status classification	n.	status classification
Visit 2 status	Chicks	3[1]	successful	52	successful	568	successful
	Empty nest	6	attempt (no chicks)	6	attempt (no chicks)	59	failed
	Trace	12	attempt (no chicks)	28	attempt (no chicks)	72	failed
	No nest visible (with adult remaining present at site)	63 (7)	site only	69	attempt (no chicks)	80	failed
	Contents unknown	3	unknown	6	unknown	16	unknown

[1]Plus an extra 8 nests with chicks that were not noted on visit 1 but had chicks visit 2

* including 1 complete but empty nest

Table B 7: Fate of monitored nests at each installation in 2021.

Installation	Nests Failed	Nests Successful	Percentage Failed	Percentage Successful
UKSNS15	9	19	32%	68%
UKSNS16	53	242	18%	82%
UKSNS08	130	307	30%	70%
UKSNS01		1	0%	100%
UKSNS14	10	16	38%	62%
UKSNS06	8	49	14%	86%

Table B 8: Number of nests of each status at respective installations in July 2021.

	Nests surveyed [1]	with chicks	No trace of existing nest	Trace nest	Complete but empty nests	fledged chicks on structure away from nests
UKSNS16	295	242	17	21	15	4 (+2 seen on water)
UKSNS15	28	19	6		3	2
UKSNS14	26	16	7	2	1	0
UKSNS08	437	307	47	45	38	17 (+2 fledged on to vessel)
UKSNS06	57	49	3	4	1	0
UKSNS01	1	1				0

[1] Where nest contents were able to be assessed

Table B 9: Productivity as recorded by June-July 2021 surveys at each installation (mean number of number of chicks fledged per pair).

Installation	AONs	Number of chicks size M or above	Number of small chicks (SM + S)	number chicks predicted to fledge (+ 50% small chicks)	Productivity
UKSNS15	28	23	1	23.5	0.84
UKSNS16	296	332	1	332.5	1.12
UKSNS08	440	410	18	419.0	0.95
UKSNS01	1	1		1.0	1.00
UKSNS14	26	15	3	16.5	0.63
UKSNS06	57	64		64.0	1.12

[1] Where nest contents were able to be assessed

Table B 10: How breeding success in 2021 varied with aspect for each installation (Success is shown as mean number of chicks per nest with total number of nests present in brackets)[1]

Aspect nest facing	UKSNS15	UKSNS16	UKSNS14	Grand Total
N	0.80 (5)	1.06 (116)	NA2	1.05 (121)
E	0.81 (8)	1.26 (66)	0.79 (14)	1.14 (88)
S	0.00 (1)	1.00 (85)	NA	0.99 (86)
W	0.93 (14)	1.41 (29)	0.46 (12)	1.08 (55)

Aspect nest facing	UKSNS08	UKSNS06	UKSNS01	Grand Total
NE	0.99 (107)	1.21 (24)	NA	1.03 (131)
SE	0.87 (124)	1.08 (13)	NA	0.89 (137)
SW	1.00 (107)	1.05 (20)	NA	1.01 (127)
NW	1.02 (95)	NA	1 (1)	1.02 (96)

[1] Nests where aspect was not recorded or where nest contents could not be established were omitted- this is why nest numbers may differ from AON totals)
[2]NA = no nests present on this face

Table B 11: How breeding success in 2021 varied with location within installation (Success is shown as mean number of chicks per nest with total number of nests present in brackets).

Installation	Inner structure (i.e. below)	Outer structure (i.e. sides)
UKSNS15	0.80 (5)	0.85 (23)
UKSNS16	1.14 (270)	0.90 (26)
UKSNS08	0.99 (100)	0.96 (333)
UKSNS01	NA (0)	1 (1)
UKSNS14	NA (0)	0.63 (26)
UKSNS06	1.12 (57)	NA (0)
Total across all installations	1.10 (432)	0.92 (409)

Table B 12: How breeding success in 2021 varied with location and aspect within installation (Success is shown as mean number of chicks per nest with total number of nests present in brackets).

	Inner		outer	
Aspect	*Productivity*	*N nests*	*Productivity*	*N nests*
N	1.07	99	0.98	22
NE	1.15	27	1.0	104
E	1.26	66	0.80	22
SE	0.94	25	0.88	112
S	1.03	77	0.67	9
SW	0.95	44	1.04	83
W	1.36	33	0.66	22
NW	1.09	61	0.91	35

Table B 13: Physical description of installations where kittiwake are breeding based on subjective assessment from digital images. Locations where birds were recorded breeding are highlighted in green, locations where were nests not present in blue.

Installation	Shape	Number of structures	Orientation	Ledges present on all sides?	Ledges present below level 1 (lowest level)	Ledges present below upper levels	Ledges present below Helideck
UKSNS01	Rectangular	single	NE-SW	Some – very narrow in places but some locations wider ledges exist	Yes	Yes	Yes – but narrower than those where nests are present
UKSNS06	Rectangular	single	NE-SW	Yes	Yes	Yes	Yes – partially overhanging water
UKSNS08	Rectangular	single	NE-SW	Yes	Yes	Yes	No ledges present– directly over stricture with many cross beams
UKSNS11 COMPLEX	Multiple rectangular adjoined with walkways	Multiple (6-7 platforms)	Multiple orientations	Yes	Yes	Yes	Yes – but narrower than other I-beams on structure. Wires below outer edge.
UKSNS12	Rectangular	single	N-S	Yes	Yes	Yes	Yes – but many cross beams below structure. Wires below outer edge.
UKSNS14	Rectangular – legs only	single	N-S	Yes (Only two aspects E and W facing available)	Yes	No – upper sections of platform removed	No – upper sections of platform removed
UKSNS15	Rectangular	single	N-S	Yes– narrow in places but some locations wider ledges exist	Yes	Very few	Yes- only on outer edge, rest is directly over structure so no access beneath.

Installation	Shape	Number of structures	Orientation	Ledges present on all sides?	Ledges present below level 1 (lowest level)	Ledges present below upper levels	Ledges present below Helideck
UKSNS16	Rectangular	single	N-S	Yes – mainly on S and N sides, few available on E and W	Yes	Yes	Not visible - may be very low ledges below also many cross beams below structure. Wires below outer edge.

4.1.2 Breeding success of offshore kittiwake populations

4.1.2.1 Estimated breeding productivity ranged from 0.6 chicks per pair to 1.12 chicks per pair (mean= 0.95 chicks per pair). The larger colonies generally had higher breeding success than the smaller installations **(Table B 9)**. UK national mean productivity for kittiwake is 0.69 (Horswill and Robinson 2015), which was exceeded by the mean productivity recorded at all but one colony on the installations surveyed by the current study. The latter productivities were also higher than the mean for coastal colonies on the east coast of the UK (0.819; Horswill and Robinson (2015)). One platform (UKSNS14) that was partially decommissioned where the only nesting ledges available were on the struts, had the lowest productivity rates (**Table B 9**). Of those nests with chicks, mean brood size across all installations was 1.37 (range 1- 1.39) chicks per pair with some broods of three observed namely in the larger colonies (UKSNS16 2 nests and UKSNS08 6 nests). However, the mean brood size takes no account of the number of chicks that are likely to fledge.

4.1.2.2 The duration between visit 1 and visit 2 was approximately 49 days. The time taken from laying of the first eggs to chicks fledging in kittiwake is between 58 – 86 days (Robinson 2015), with time from hatching to fledging 33-54 days. No chicks were observed during visit 1 but adults brooding small chicks could potentially have been present but recorded as apparently incubating. If chicks hatched shortly after visit 1, then the time interval between the two surveys would allow some of the earlier broods to have fledged before visit 2. However, kittiwake chicks begin to fly and may depart the colony for up to 24-hours before they become independent (fledged) but will return to the nest to roost and be fed by their parents (Thompson et al. 2020). The kittiwake fledging period begins around 41.5 days after hatching, and chicks finally leave the colony on average 10 days after their first flight (age 51.5 days), though some may still return to the colony up to 61 days after hatching (Coulson 2011). A small number of recently fledged juveniles were observed at some sites on structures away from the nest and in flight close to the colony (see **Table B 8**).

4.1.2.3 Overall, a combined total of 634 nests successfully raised chicks, with 210 nests apparently failed **(Table B 7)**. 65 nests that were traces or sites on visit 1 became full nests and chicks were recorded on visit 2. 122 sites were recorded as a breeding attempt (i.e. nests were recorded as either trace nest or IND on visit 1) and were subsequently recorded as complete but empty or trace nests, it was assumed these nests were unlikely to have reached chick stage. 63 sites were recorded as IND occupying breeding sites but subsequently did not construct nests. There were 26 sites where nest contents could not be reliably established and therefore breeding success was recorded as unknown. Nest failure rates varied on an installation by installation basis with a higher proportion of nests making it to chick stage at installation UKSNS16 and UKSNS06. At both of those installations, most birds nested below the platform structures **(Table B 7)**.

4.1.3 Variation in breeding success within installations

4.1.3.1 Productivity did not vary much between nest site location on a platform (**Table B 10** and **Table B 11**), though visual observations suggested nests in areas that were more sheltered seemed to have a higher success rate. 21% of nests that were under structures failed whereas 29% failed when located on the sides. Overall breeding success was slightly higher if nests were located in areas below the structures (**Table B 11**). There was a slight decrease in productivity for nests facing a southerly aspect (**Table B 10)**. However, the direction nests face may have a lesser impact on productivity than whether nests are more sheltered from the wind and precipitation. This is suggested (see **Table B 12**) by S, W, SE and NW facing nests showing lower productivity when located on the outer edges of an installation than underneath. However, these patterns observed must be considered alongside the physical availability of suitable nesting sites i.e. ledges deemed to be a suitable size, at each location. Some installations were oriented north-south so had nesting space available only on aspects facing north, east, south or west, whereas others were oriented NE to SW meaning only NE, NW, SE and SW aspects were applicable (**Table B 10**). A subjective assessment of the locations available to breeding kittiwake is made in **Table B 13.** A finer scale assessment of the micro siting of nests could highlight differences in breeding success within the broader categories investigated in this report e.g. differences in site features along each side or below each installation. Ideally measurements of ledge dimensions and a quantitative measure of the level of shelter would be useful parameters to include if these could be gained in future studies. However, this may require access to the platforms themselves for measurements to be taken.

4.2 Updated distribution information for SNS installations.

4.2.1.1 During the July surveys an additional 12 installations to those surveyed in June were observed. Kittiwake presence was recorded at these installations at a greater distance than installations surveyed for productivity; 7 were surveyed at 500 m covering all visible sides of the installation and 5 at a distance greater than 500 m (on passage) covering only part (1-3 sides) of each platform. Of those installations, one was found to have breeding kittiwake present and one unconfirmed presence of breeding birds on account of the distance over which it was viewed and resulting in low image quality of the photographs taken. A further three installations had some kittiwakes present but with no evidence of breeding whilst no kittiwakes were recorded at the remaining seven installations (**Table B 15).** On approach to occupied installations with more than 20+ nests a number of birds flying around the installation were recorded. On partially surveyed installations where no kittiwakes were visible on the structure and no kittiwakes were observed in the vicinity it was assumed that breeding kittiwakes were absent. The presence or absence of breeding kittiwakes has been recorded using Orsted boat based surveys for a total of 32 installations in the UK SNS during single surveys in June and July 2021 (**Table B 14**, **Table B 15**, **Figure B 3**).

Table B 14: Areas covered and presence-absence results from June and July 2021 offshore surveys.

Location – OGA Block	Total no. of installations in block	No. of installation s surveyed	% of installation s	No. of installations at which birds were:		
				Confirmed as breeding	Present but not breedin g	Absent (apparently absent11)
42	9	3	33%		1	1 (1)
43	5	3	60%		1	2
44	15	0	0%			
47	12	4	33%	2		1(1)
48	41	13	32%	5	3	2(3)
49	75	9	12%	2		5 (2)

Table B 15: The presence and status of kittiwake on O&G installations surveyed by two boat-based surveys in June and July 2021. Y-yes, P-present not breeding, A-absent, AA-apparently absent.

Platform ID:	*OGA block*	*Proportion of platform surveyed and distance*	*No. of faces surveyed*	*Breeding confirmed*	*No. of AON in June survey*	*No. of AONs in July survey (+ notes on kittiwakes present)*
UKSNS01	*47*	*WHOLE (<500 m)*	*All*	*Y*	*1*	*1*
UKSNS02	*43*	*WHOLE (<500 m)*	*All*	*P*	*0*	-
UKSNS03	*42*	*WHOLE (<500 m)*	*All*	*P*	*0*	*0 (27 birds on structure)*
UKSNS04	*43*	*WHOLE (<500 m)*	*All*	*A*	*0*	-
UKSNS05	*43*	*WHOLE (<500 m)*	*All*	*A*	*0*	-
UKSNS06	*49*	*WHOLE (<500 m)*	*All*	*Y*	*47*	*57*
UKSNS07	*49*	*WHOLE (<500 m)*	*All*	*A*	*0*	
UKSNS08	*49*	*WHOLE (<500 m)*	*All*	*Y*	*409*	*440*
UKSNS09	*49*	*WHOLE (<500 m)*	*All*	*A*	*0*	-
UKSNS10	*49*	*WHOLE (<500 m)*	*All*	*A*	*0*	-
UKSNS11 COMPLEX	*48*	*WHOLE (<500 m)*	*All*	*Y*	*266*	-
UKSNS12	*48*	*WHOLE (<500 m)*	*All*	*Y*	*260*	-
UKSNS13	*48*	*WHOLE (<500 m)*	*All*	*A*	*0*	-

[11] Numbers indicate the number of installations where kittiwakes were found to be present or absent in each location, installations which were not fully surveyed but which were not thought to have breeding birds on passing were recorded as ' apparently absent'.

Platform ID:	OGA block	Proportion of platform surveyed and distance	No. of faces surveyed	Breeding confirmed	No. of AON in June survey	No. of AONs in July survey (+ notes on kittiwakes present)
UKSNS14	*48*	*WHOLE (<500 m)*	*All*	*Y*	*24*	*26*
UKSNS15	*48*	*WHOLE (<500 m)*	*All*	*Y*	*25*	*28*
UKSNS16	*48*	*WHOLE (<500 m)*	*All*	*Y*	*362*	*372*
UKSNS17	*42*	*PARTIAL (>500 m)*	*1*	*AA*	*0*	*-*
UKSNS18	*49*	*PARTIAL (>500 m)*	*2*	*AA*	*0*	*-*
UKSNS19	*49*	*PARTIAL (>500 m)*	*1-2*	*AA*	*0*	*-*
UKSNS20	*48*	*PARTIAL (>500 m)*	*1-2*	*AA*	*0*	*-*
UKSNS21	*49*	*WHOLE (>500 m)*	*All*	*A*	*-*	*0*
UKSNS22	*49*	*WHOLE (>500 m)*	*All*	*A*	*-*	*0*
UKSNS23	*48*	*WHOLE (>500 m)*	*All*	*P*	*-*	*0 (1 bird sat on top ledge)*
UKSNS24	*48*	*WHOLE (>500 m)*	*All*	*P*	*-*	*0 (1 bird sat on top ledge)*
UKSNS25	*48*	*WHOLE (>500 m)*	*All*	*A*	*-*	*0*
UKSNS26	*48*	*WHOLE (>500 m)*	*All*	*P*	*-*	*0 (2 birds sat on helideck)*
UKSNS27	*42*	*PARTIAL (>500 m)*	*2-3*	*P*	*-*	*0 -(c. 10 birds present on ledges breeding unconfirmed (nests not clearly visible))*
UKSNS28	*47*	*PARTIAL (>500 m)*	*2-3*	*Y*	*-*	*c. 100 (nests mainly on NW side)*
UKSNS29	*47*	*PARTIAL (>500 m)*	*2-3*	*AA*	*-*	*0*
UKSNS30	*47*	*WHOLE (>500 m)*	*All*	*A*	*-*	*0*
UKSNS31	48	*PARTIAL (>500 m)*	2	AA	-	0
UKSNS32	48	*PARTIAL (>500 m)*	2	AA	-	0

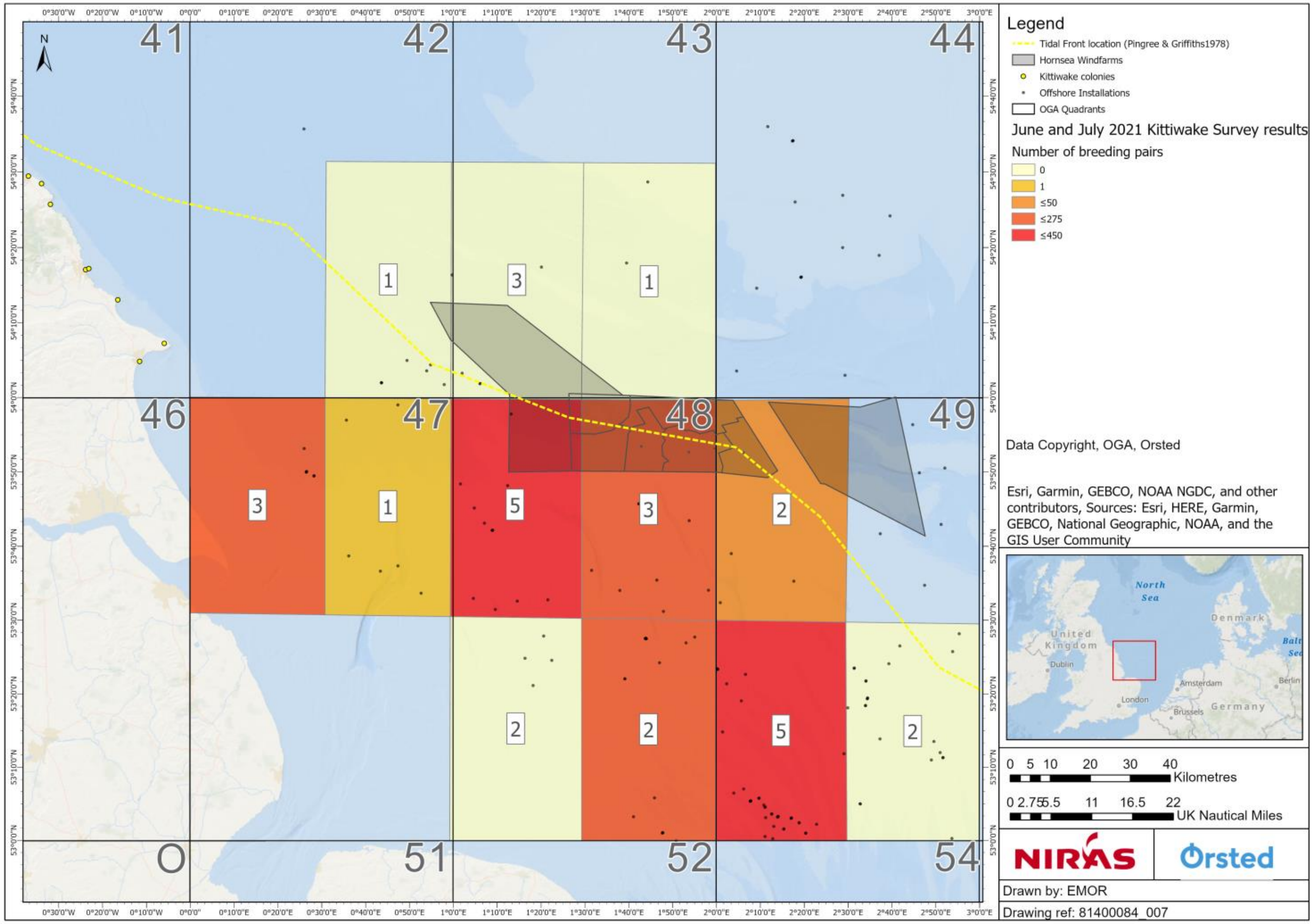

Figure B 3: Number of breeding kittiwake in each OGA block location with the number of installations surveyed in June and July 2021 shown in white boxes. Approximate position of tidal front and Hornsea windfarm area is also shown.

5 Conclusions

5.1.1.1 The two surveys in June and July, successfully acquired information on breeding productivity at six O&G installations. Most of these offshore colonies had higher productivity than the UK national average and regional average from British east coast colonies. During July's survey, a small proportion of chicks had already fledged which is likely to mean productivity rates may be underestimated, as some fledged chicks may not have been present at the colony during the survey. Results are suggestive that nests in more sheltered locations within a platform are slightly more productive than exposed sites. However, these differences in productivity cannot be fully disentangled from location specific variables, such as, size and location of the colony which could be influenced by proximity to food resources etc. and impact breeding productivity. The factors driving birds' choice of nesting site will be influenced by the availability of suitable nesting sites at a installation, which could be driven by design features i.e. where and if suitably sized ledges are available, the use of bird deterrent devices and the level of human disturbance/operational activities at a platform.

5.1.1.2 In addition to the above mentioned six colonies, 12 installations were surveyed from a distance (>500 m). This identified one more occupied colony was observed with over 100 nests most with large chicks indicative of a good breeding season. In total, Hornsea Project Four has surveyed the status of breeding kittiwake at 32 offshore installations in the SNS region. Images of at least two sides (generally of four sided structures) have been obtained for all of these structures. Detailed information on the location and status of kittiwake breeding on these installations have been documented (and mapped) for six installations at both the stages of incubation (June) and chick rearing (July), with a further two installations mapped during incubation only.

5.1.1.3 The current studies survey in July has provided further data to support the conclusions drawn in survey report 1. It has further increased our understanding of factors influencing the distribution of breeding kittiwake at installations in the offshore environment. The results show productivity offshore is comparable to, if not better than that reported at coastal sites and that fine scale micro siting of nest site features could potentially enhance breeding productivity. Visual assessments of photographic evidence suggests that breeding success at some installations may be limited by the number of more favourable breeding locations available (e.g. broader sheltered ledges compared to narrower more exposed ledges).

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Appendix C
Survey Report from the July Aerial Survey of nesting birds of oil and gas platforms in the southern north sea

Aerial Survey of Nesting Kittiwake on Offshore Platforms
Orsted
P00006267
September 2021

Sam Evans, Beth Goddard, Sean Sweeney, Simon Warford, Matthew Doyle, Ricki McCloud

1 Introduction

1.1.1.1 Orsted Hornsea Four Ltd (Hornsea Four) contacted APEM Ltd (APEM) about the feasibility of using aerial digital survey methods to collect data on the nesting population of (black-legged) kittiwakes (Rissa tridactyla) that have colonised artificial structures in the North Sea. The survey data are intended to be used to inform the evidence base of the areas and types of offshore platforms that kittiwakes are nesting on to inform the future site selection and design process for the selection of artificial nest compensation measures in the Southern North Sea.

1.1.1.2 Following consultation between APEM and Hornsea Four it was agreed that an initial 'proof of concept' (PoC) flight would be undertaken, which occurred on the 18th May 2021. The PoC survey took place covering an offshore platform located in the Southern North Sea to test a new survey method to collect data on kittiwakes associated with such offshore structures. Following the PoC survey Hornsea Four commissioned APEM to undertake aerial digital surveys of a wider pool of 21 offshore oil and gas platforms located in the Southern North Sea (**Figure C 1**). Due to the nature of the requests from O&G operators the platform identities and owners must remain anonymous and as such a numbering system has been assigned to them for the purpose of this report. The ultimate purpose of surveying the 21 offshore platforms was to determine the number of nesting pairs of kittiwakes at each platform. Additional information was collected on the number of other species observed on the offshore platforms, their behaviour and other anecdotal information such as human activity and disturbance.

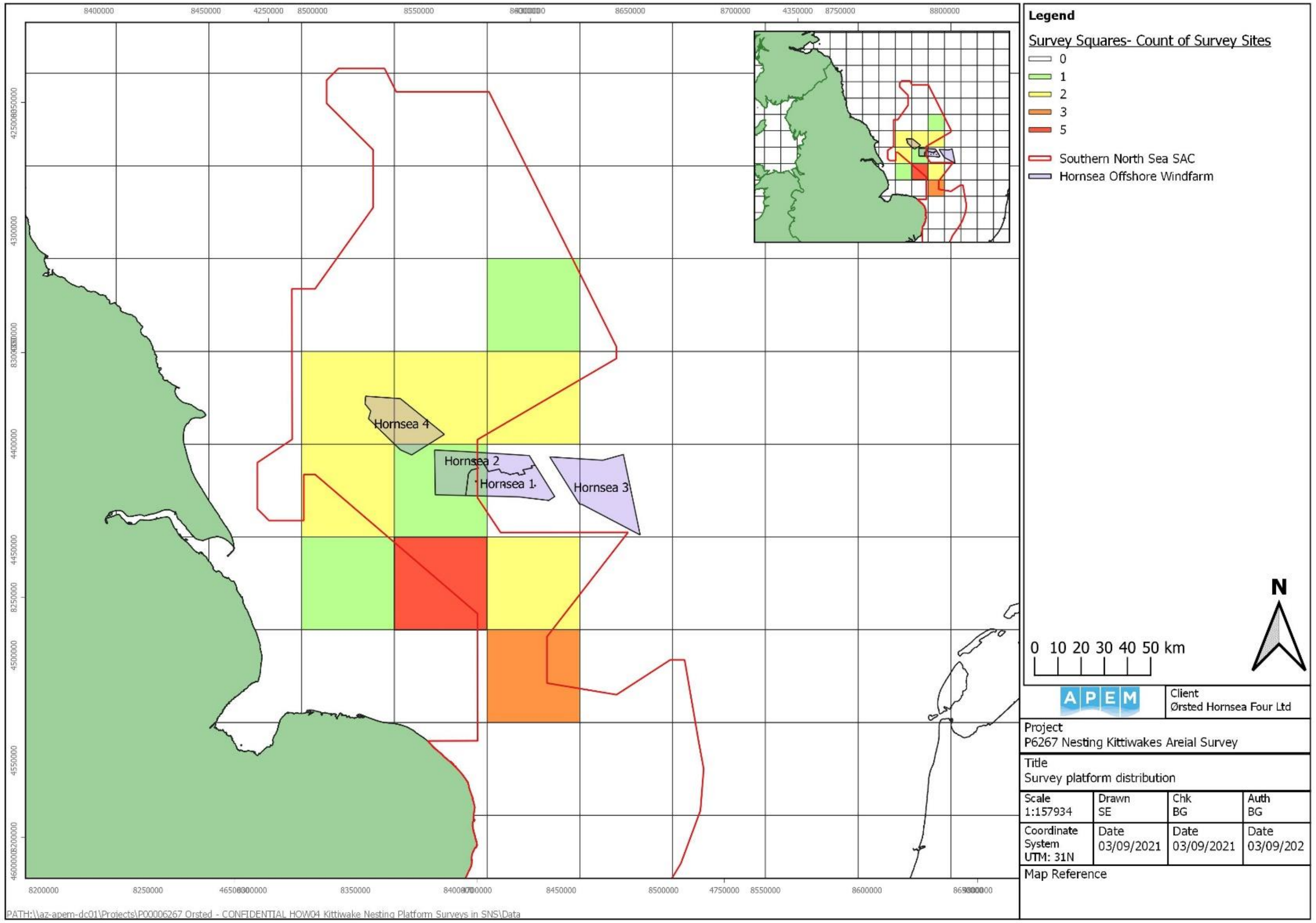

Figure C 1: Location of the offshore platforms surveyed for nesting kittiwakes (platform count depicted by cell colour, each cell is 40 km²).

2 Summary of Survey

2.1.1.1 The aerial digital survey was undertaken across two consecutive days, on the 15th and 16th July 2021, using an MX15HD camera system fitted to a Diamond DA-42 MNG twin-engine survey aircraft. The survey involved high-definition digital video image collection.

2.1.1.2 No health and safety issues were reported during the survey.

3 Aerial Survey Methodology

3.1.1.1 At UK onshore / coastal colonies, some kittiwakes are known to return to breeding sites as early as March or April, though the main attendance occurs between May and July and some not departing until August (Furness, 2015). For the purpose of this survey, it was assumed that kittiwake breeding behaviour was of similar nature at the offshore colonies surveys (Thompson, 2021). As such, the aerial digital surveys of all 21 offshore platforms were carried out on the 15th and 16th July 2021 to coincide with kittiwake main attendance at their colonies during the UK breeding season.

3.1.1.2 The surveys were undertaken in optimal weather conditions that did not limit the ability to identify bird species recorded. The survey conditions are listed below and are those that have been acceptable to the UK Statutory Nature Conservation Bodies (SNCBs) for collecting seabird data in the marine environment:

- Cloud base: > 1,300 ft;
- Visibility: > 5 km;
- Wind speed: < 30 knots; and
- No icing conditions.

3.1.1.3 The aerial digital survey comprised of the aircraft orbiting each offshore platform to capture video imagery of the whole platform. The aircraft orbits were conducted at a distance of at least 500 m away from each structure and ensured that imagery was captured directly opposite the offshore platforms and slightly above following current guidelines for survey methods at offshore installations (Thompson, 2021). Aircraft altitude varied depending on the offshore platform structure. Filming was continuous as the aircraft completed the orbits of each offshore platform. In addition, a thermal video stream was also collected alongside the video stream, which was used where necessary to aid the location of birds on the structure in areas that were more difficult to observe.

4 Image Analysis

4.1.1.1 The following information was recorded during each survey for all 21 offshore platforms:

- Date;
- Time;
- Offshore platform location ID;
- Species (or group) ID;
- Count (where possible including information on the number of individuals, number of apparently occupied nests, number of trace nests with adults present, number of unattended trace nests and unattended well-built nests);
- Age (where possible); and
- Behaviour (in flight or sitting).

4.1.1.2 The video imagery recorded from the survey flights was encoded in a H.265 MPEG-TS format and analysed by APEM ornithologists to independently locate, identify and count the birds present at each offshore platform. The video imagery was viewed using VLC Player in real time to identify areas where kittiwakes were present. Where larger numbers were present or in areas with viewing limitations the imagery was paused to conduct counts of birds. Following the imagery being reviewed a proxy measurement of 'Apparently Occupied Nests' (AON) was employed, which was determined either by two adult kittiwakes sitting near each other on a nest (if visible) with a larger gap between the next single or pair of birds (and / or nest) than the supposed pair (**Figure C 2**) or the appearance of a sitting bird on a nest (if visible), which could be assumed to be part of a pair. This did not apply to pairs present on helipads, as it was assumed that helipads would be an unlikely breeding location (**Figure C 3**) and no nests were observed on the helipads of any offshore platforms from this survey programme.

4.1.1.3 Each APEM image analyst counted the total number of adult and first summer (non-breeding) kittiwakes sitting or perched on each offshore platform and estimated the number of AONs following the method described above. An average count of each category was calculated (**Table C 1**). As birds were either constantly landing or taking off some of the offshore platforms flying birds were not counted separately.

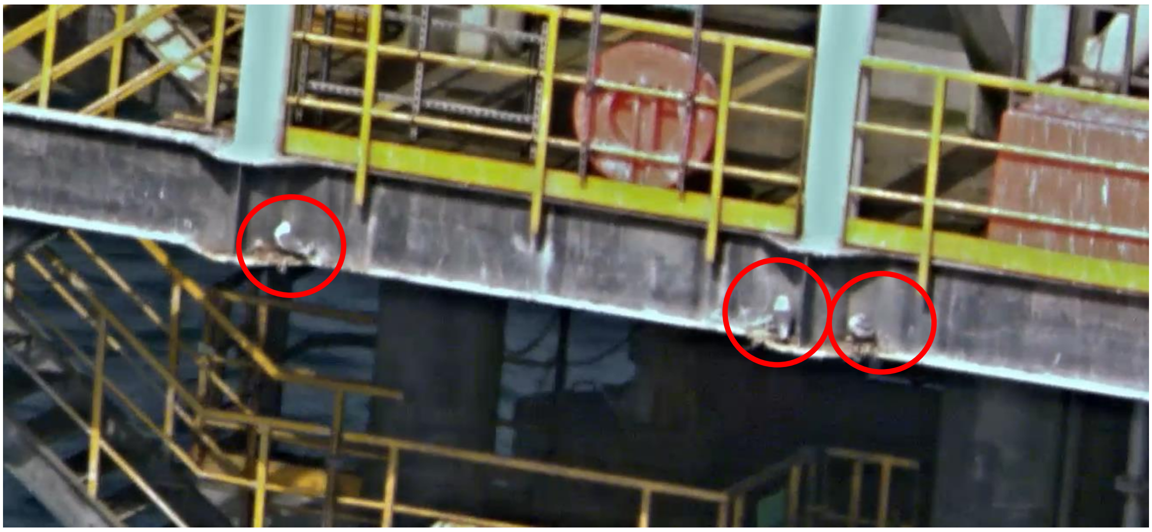

Figure C 2: Examples of AONs (red circles). The highlighted birds are in exemplar as to nesting birds, clearly sitting upon nesting material and perfectly displaying typical spacing behaviour.

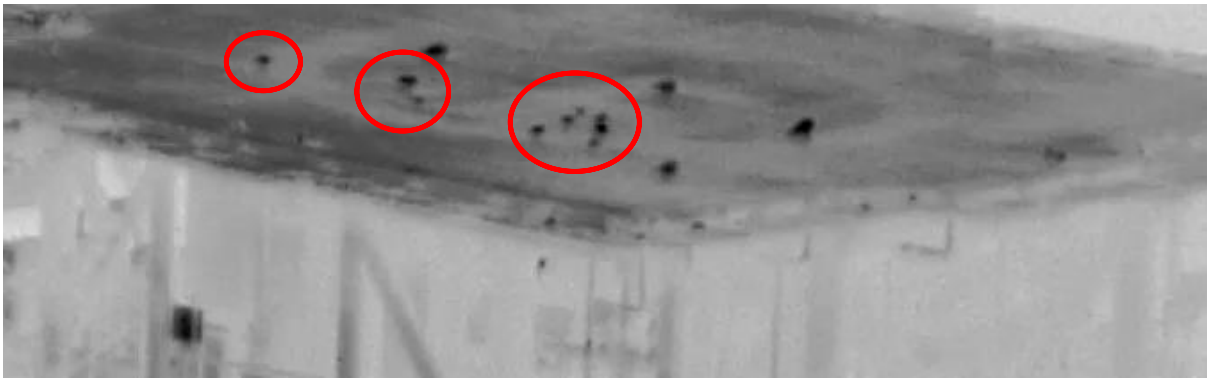

Figure C 3: Birds stood on top of the helipad captured in IR imagery. The circled birds are likely kittiwakes, but the location is unlikely for a nest so were not included for estimates of AONs. The larger individuals (not circled) are possibly great black-backed gulls or herring gulls.

Figure C 4: Examples of great black-backed gulls resting on the lower struts of a platform, providing evidence that this species is easily differentiated from the target kittiwakes by both size and colouration within the survey imagery.

5 Results

5.1 Results for each Offshore Platform

5.1.1.1 The results of the surveys, including notes on other species recorded or other activities at each site, are outlined for each of the 21 offshore below, whilst the number of kittiwakes (and AONs) are presented in **Table C 1** in **Section 5.3**. Following results of each individual offshore platform the rough distribution of kittiwakes in the area surveyed is presented in **Figure C 5** and **Figure C 6** in **Section 5.4**.

5.2 Offshore Platform 1

5.2.1.1 At Offshore Platform 1 a total of 20 individual kittiwakes were recorded with an estimated 11 AONs, of which chicks were observed within three AONs. An additional four large gulls were also present. No human activity was observed.

5.2.2 Offshore Platform 2

5.2.2.1 No kittiwakes were present at Offshore Platform 2. High levels of human activity were observed, which may contribute to disturbance at this platform being at a level that makes it unattractive to kittiwakes.

5.2.3 Offshore Platform 3

5.2.3.1 At Offshore Platform 3 a total of 36 individual kittiwakes were recorded, but no AONs were observed, since most of the birds observed were sitting on the helipad or in flight. No human activity was observed, giving no apparent cause for a lack of AONs.

5.2.4 Offshore Platform 4

5.2.4.1 At Offshore Platform 4 a total of 21 individual kittiwakes were recorded, but no AONs were observed. No human activity was observed; however eight large gulls were present which may have contributed to no AONs being recorded.

5.2.5 Offshore Platform 5

5.2.5.1 At Offshore Platform 5 a total of 62 individual kittiwakes were recorded and an estimated seven AONs, though no chicks were observed. No human activity was observed but two great black-backed (Larus marinus) gulls and two unidentified large gulls were recorded which may have contributed to low numbers of AONs.

5.2.6 Offshore Platform 6

5.2.6.1 At Offshore Platform 6 a total of nine individual kittiwakes were recorded and an estimated nine AONs, though no chicks were observed. No human activity was observed.

5.2.7 Offshore Platform 7

5.2.7.1 At Offshore Platform 7 a total of five individual kittiwakes were recorded and an estimated two AONs, though no chicks were observed. No human activity was observed, but approximately 50 large gulls were recorded which may have contributed to low observed numbers of kittiwakes.

5.2.8 Offshore Platform 8

5.2.8.1 At Offshore Platform 8 a total of 65 individual kittiwakes were recorded and an estimated 40 AONs, of which chicks were observed within five AONs. No human activity was observed.

5.2.9 Offshore Platform 9

5.2.9.1 At Offshore Platform 9 a total of 285 individual kittiwakes were recorded and an estimated 115 AONs, of which chicks were observed within 20 AONs. No human activity was observed, but approximately 10 great black-backed gulls were recorded which may contribute to nest disturbances. Furthermore, 15 auks were recorded, 5 of which were guillemots (*Uria aalge*), whilst 10 were either guillemots or razorbill (*Alca torda*).

5.2.10 Offshore Platform 10

5.2.10.1 At Offshore Platform 10 a total of 143 individual kittiwakes were recorded and an estimated 30 AONs, though no chicks were observed. No human activity was observed, but approximately 10 large gulls were recorded which may have contributed to nest disturbances. A further pair of auks were observed, which were either guillemots or razorbill.

5.2.11 Offshore Platform 11

5.2.11.1 At Offshore Platform 11 a total of 171 individual kittiwakes were recorded and an estimated 61 AONs, though no chicks were observed. Human activity was observed but often in areas distant to those the kittiwakes were nesting in.

5.2.12 Offshore Platform 12

5.2.12.1 No kittiwakes were recorded at Offshore Platform 12. No human activity was observed or apparent cause for lack of kittiwakes.

5.2.13 Offshore Platform 13

5.2.13.1 No kittiwakes were recorded at Offshore Platform 13 and no human activity was observed. A total of seven great black-backed gulls were recorded.

5.2.14 Offshore Platform 14

5.2.14.1 At Offshore Platform 14 totals of 133 individual kittiwakes and 68 AONs, of which nine contained observable chicks, were recorded. Human activity was observed below the helipad, possibly disturbing any birds on the struts nearby.

5.2.15 Offshore Platform 15

5.2.15.1 Totals of 481 individual kittiwakes and 257 AONs were recorded at Offshore Platform 15. Of the 257 AONs recorded 10 contained observable chicks. No human activity was observed but approximately 30 great black-backed gulls were observed.

5.2.16 Offshore Platform 16

5.2.16.1 No kittiwakes were recorded at Offshore Platform 16, however seven great black-backed gulls were recorded.

5.2.17 Offshore Platform 17

5.2.17.1 No kittiwakes were recorded at Offshore Platform 17, however 10 unidentified large gulls were observed. No human activity was observed.

5.2.18 Offshore Platform 18

5.2.18.1 No kittiwakes were recorded at Offshore Platform 18. Human activity was observed which may have contributed to the lack of birds present.

5.2.19 Offshore Platform 19

5.2.19.1 No kittiwakes were recorded at Offshore Platform 19. No human activity was observed. Giving no apparent cause for lack of kittiwakes.

5.2.20 Offshore Platform 20

5.2.20.1 No kittiwakes were recorded at Offshore Platform 20. No human activity was observed. Giving no apparent cause for lack of kittiwakes.

5.2.21 Offshore Platform 21

5.2.21.1 Totals of 65 individual kittiwakes and 17 AONs were recorded at Offshore Platform 21. No AONs contained observable chicks. No human activity was observed. Furthermore, approximately seven great black-backed gulls were recorded.

5.3 Kittiwake Results

5.3.1.1 A summary of all kittiwakes recorded and observed at each of the 21 offshore platforms is presented in **Table C 1**. The results show that evidence in support of breeding kittiwakes was recorded at 11 of the 21 offshore platforms included in the surveys. A total of 617 kittiwake AONs were recorded across all 11 offshore platforms with breeding birds in evidence. Of the offshore platforms with breeding birds present those with the highest number of AONs were Offshore Platform 9 (115 AONs) and Offshore Platform 15 (257 AONs). Of the 11 offshore platforms with breeding kittiwakes present only two recorded human activities on the platforms, whilst all others had no activities.

Table C 1: The estimated number of kittiwakes on the surveyed offshore platforms during the July 2021 survey.

Platform ID	Kittiwakes						Human activity
	Total No. Perched (adults/fledged immature)	Est. No. Flying	Total no. Individuals	Total AON (pairs)	Est. No. Immature	No. Nests Observed with Chicks	
1	14	6	20	11	0	3	None
2	0	0	0	0	0	0	Yes
3	33	3	36	0	0	0	None
4	19	2	21	0	0	0	None
5	46	16	62	7	0	0	None
6	6	3	9	9	0	0	None
7	3	2	5	2	0	0	None
8	60	5	65	40	0	5	None
9	220	65	285	115	0	20	None
10	118	25	143	30	0	0	None
11	140	30	171	61	0	0	Yes
12	0	0	0	0	0	0	None
13	0	0	0	0	0	0	None
14	113	20	133	68	0	9	Yes
15	451	0	481	257	0	10	None
16	0	0	0	0	0	0	None
17	0	0	0	0	0	0	None
18	0	0	0	0	0	0	Yes
19	0	0	0	0	0	0	None
20	0	0	0	0	0	0	None
21	57	8	65	17	1	0	None
Total	**1280**	**215**	**1496**	**617**	**1**	**47**	**-**

5.4 Kittiwake Distribution

5.4.1.1 Kittiwakes were present at 13 of the 21 offshore platforms surveyed and were located in all areas surrounding the Hornsea Offshore Wind Farms (**Figure C 5**). Breeding kittiwakes were present on offshore platforms located to the north, south and west of the Hornsea Offshore Wind Farms, however no presence of breeding kittiwakes was recorded at offshore platforms located in the north-west (**Figure C 6**).

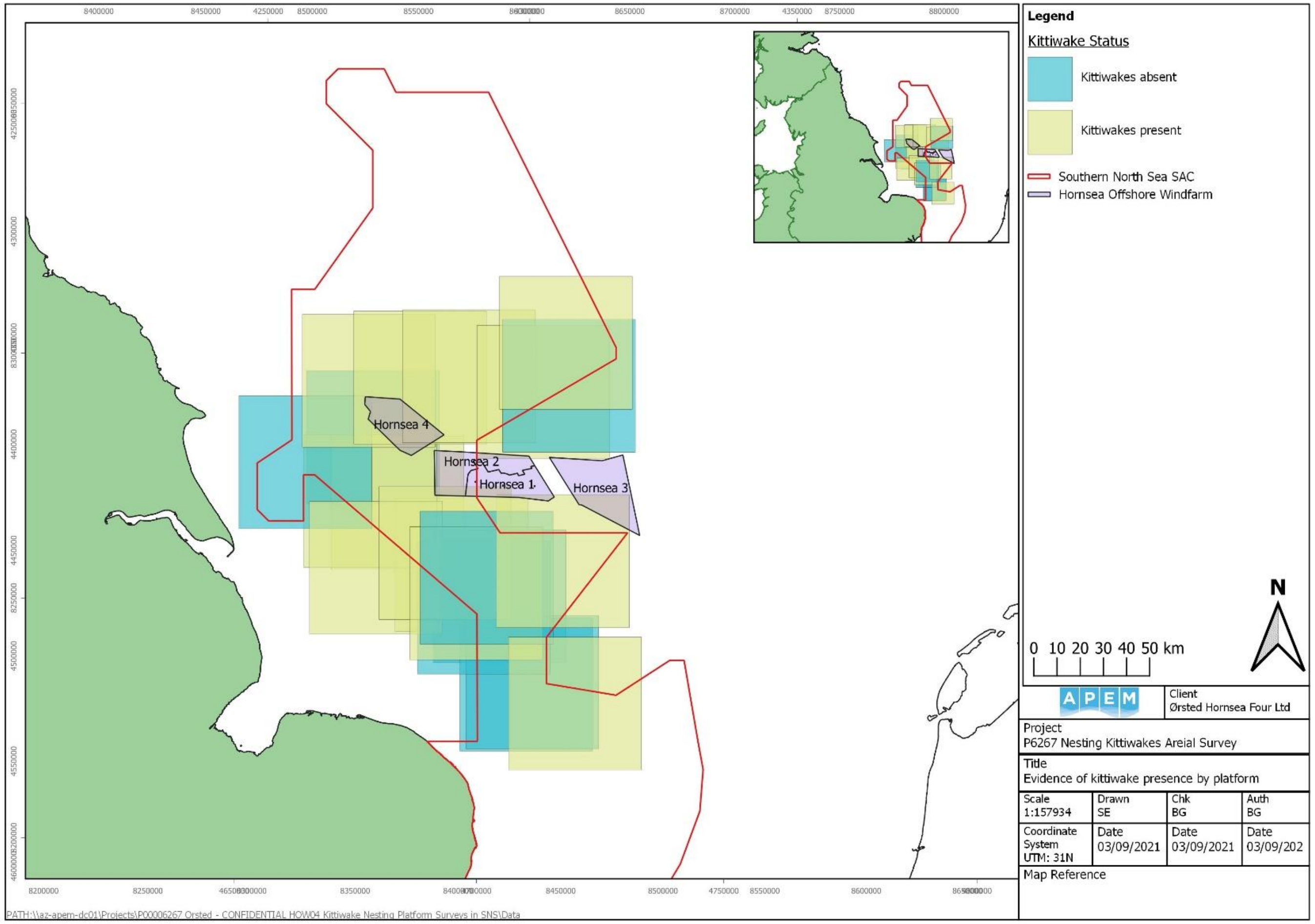

Figure C 5: Distribution of kittiwakes recorded on surveyed offshore platforms. Each square represents a surveyed offshore platform.

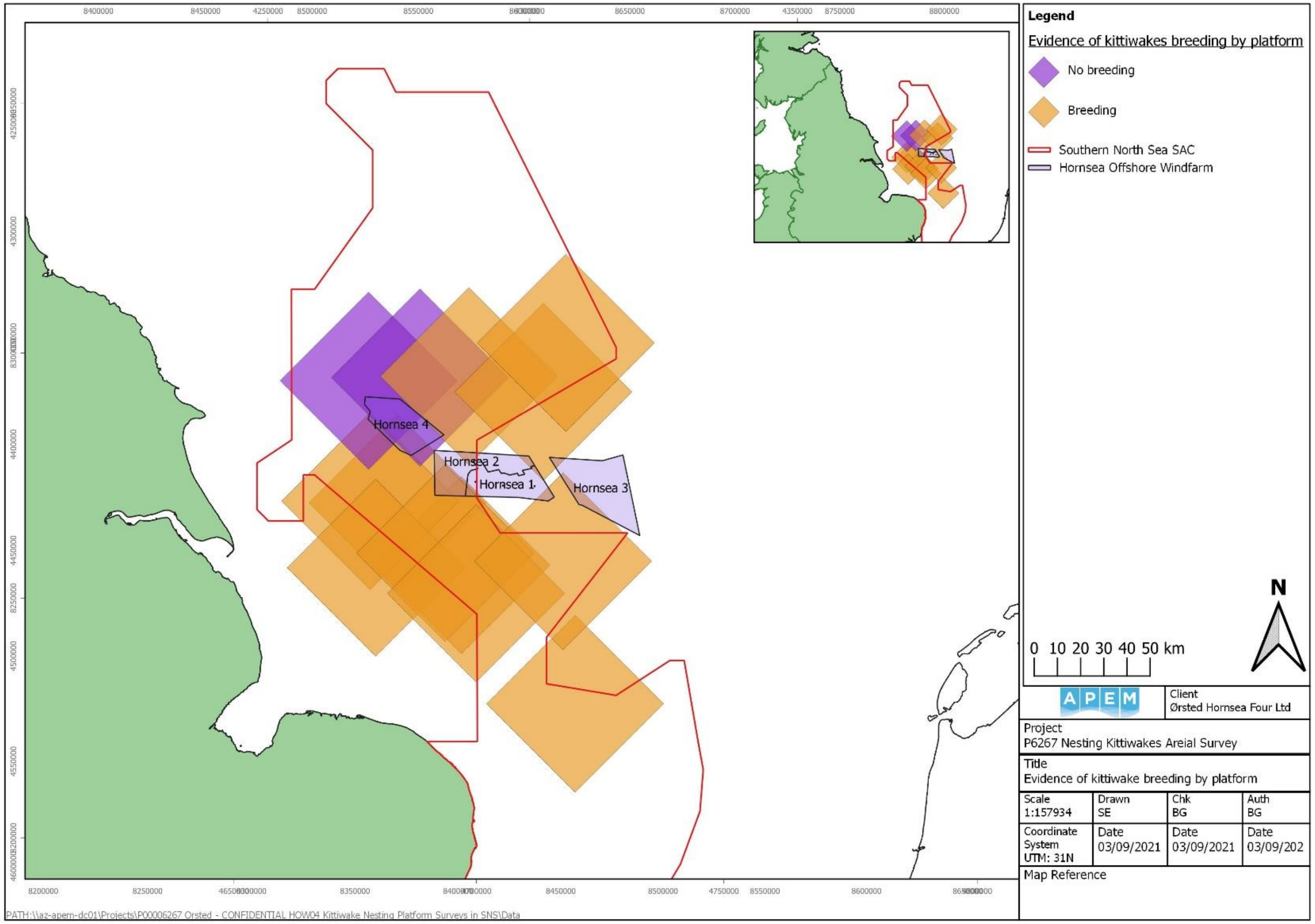

Figure C 6: Distribution of evident breeding kittiwakes recorded on surveyed offshore platforms

6 Other species

6.1.1.1 Other species of seabirds, totalling 168 individuals for all species, were also observed on the offshore platforms (**Table C 2**). Primarily, the other birds recorded were large gull species as earlier described (and visually presented in **Figure C 3** and **Figure C 4**), including great black-backed gulls and herring gulls (*Larus argentatus*). In addition to the large gulls recorded several auks (**Figure C 7**), either guillemots (*Uria aalge*) or razorbills (*Alca torda*), were recorded. Both species commonly nest in similar habitats to kittiwakes at UK coastal locations and comfortably reside within kittiwake colonies. However, no visible evidence of breeding auks was recorded during these surveys, though evidence of nests relating to this species is more difficult to prove without observing eggs or chicks directly.

6.1.1.2 Interestingly, there was no apparent evidence of species other than kittiwakes breeding on the offshore platforms themselves. It is possible both the large gulls and auks recorded during this survey programme were using the offshore platforms as foraging or resting sites rather than breeding opportunities (Lieber et al., 2019).

Figure C 7: Examples of guillemots standing on ledges near to sitting kittiwakes.

Table C 2: The estimated number of all other species on the surveyed offshore platforms during the July 2021 survey.

Platform Id	Other species	Number of birds
1	Large gull	~4
4	Large gull	8
5	Great black-backed gull	2
	Large gull	2
7	Large gull (great black-backed gull / herring gull)	~50
9	Great black-backed gull	~10
	Guillemot	5
	Guillemot / razorbill	~10
10	Large gull (great black-backed gull)	~10
	Guillemot / razorbill	2
13	Great black-backed gull	7
14	Great black-backed gull	4
15	Large gull (great black-backed gull)	~30
16	Great black-backed gull	7
17	Large gull	~10
21	Great black-backed gull	7
Totals	Total great black-backed gull	37
	Total large gulls	114
	Total guillemot / razorbill	17
	Grand Total	168

7 Discussion

7.1.1.1 The majority of surveyed offshore platforms were observed to be supporting either transitory or resident populations of kittiwakes, with 13 out of the 21 offshore platforms having some kittiwakes present. Most of the birds were seen perched along the girders and struts on the sides of the offshore platforms (**Figure C 2**) as well as beneath the helipads (which were, unfortunately, more difficult to view). These locations are the most analogous to natural sites, which kittiwakes would use to breed on such as cliffs on offshore islands and / or along coastlines, where they prefer sites on vertical cliff faces with natural ledges. All AONs observed during this survey programme were on the lips of the girders, which are comparable surfaces with respect to size and access to kittiwake's natural breeding habitat on cliff ledges (Coulson, 2011). Birds were observed using the helipads and other flat surfaces on offshore platforms, but exposed surfaces are more likely to be used as resting sites rather than nesting locations as they do not replicate natural nesting conditions and are likely to be more prone to exposure from adverse weather and predators. The helipads on the offshore platforms surveyed for this project often recorded kittiwakes sharing space with large gull species such as great black-back gulls and herring gulls.

7.1.1.2 Large gull species were not observed to be nesting on the offshore platforms, though they may be using them as resting sites during extended foraging trips from their breeding colonies (Lieber et al., 2019) or simply be non-breeding or failed breeding birds. Lieber et al. (2019) describes that offshore structures, including offshore platforms, can produce zones of increased prey species populations via increasing water mixing between different layers of the water column within the structures' prevailing wake. These increases in prey abundance may account for the size of populations supported on offshore platforms being higher than expected in comparison to natural sites (McArthur Green, 2020), since kittiwake breeding success is often linked to foraging trip length. Shorter foraging trips for kittiwakes are generally indicative of higher breeding success (Daunt et al., 2002) and the turbulence effects of the offshore platforms wake increasing foraging success within 1 km surrounding such structures (Lieber et al., 2019).

7.1.1.3 One offshore platform of note during this survey programme was Offshore Platform 8, which is structurally composed of a set of four pylons topped with multiple small ledge structures (**Figure C 8**). Considering the size of the offshore platform's structures, the population of nesting kittiwakes was proportionately considerably larger in comparison to other offshore platforms surveyed. It is assumed that the differences in this offshore platform's structures provides a greater density of prime nesting sites offering more favourable conditions in comparison to the other offshore platforms, which are mostly made up of structures which offer kittiwakes less optimised nesting sites and conditions.

Figure C 8: Examples of kittiwakes nesting on Offshore Platform 8, including observed chicks (circled in red).

7.1.1.4 The apparent preference of sites on such a small structure suggests that other offshore platforms may offer similar opportunities following simple structural changes to simulate the same qualities which make Offshore Platform 8 more appealing to breeding kittiwakes.

7.1.1.5 Equally notable is the total lack of kittiwakes on Offshore Platforms 2 and 18, all of which were observed to have plentiful human activity (**Table C 1**). It was not possible to determine if this absence was due to the presence of humans alone during this survey programme, since human activities were recorded at other offshore platforms with breeding kittiwakes, though birds were located on such offshore platforms in areas that appeared not to be exposed to such potential disturbance activities. This is likely due to the relative sizes of the offshore platforms, with Offshore Platform 11 being one of the largest surveyed and having a comparatively small human presence perhaps explaining the number of kittiwakes that it supported despite the potential for human disturbance instances.

7.1.1.6 The results of this survey provide evidence that breeding kittiwakes occur across many of the offshore platforms surveyed, with a total of 617 AONs recorded at 11 different offshore platforms. Several offshore platforms had significant numbers of AONs present, with Offshore Platform 15 having the highest number of kittiwakes recorded with an estimated total of 481 individual birds, almost all of which were arranged in breeding pairs.

7.1.1.7 The results of this survey programme also provide evidence that significant numbers of breeding kittiwakes are present across the North Sea on offshore structures, which contribute to the wider population, that have not been included in previous national counts, surveys or population estimates.

7.1.1.8 Finally, it is apparent that differences between individual offshore structures and how birds may benefit from different conditions are not yet fully understood, though the initial findings of this report suggest that such differences may have significant influence on kittiwake nesting location selection. Further investigation into kittiwake nesting preferences, optimal breeding conditions and productivity levels of AONs may be beneficial to aid future consideration of which locations and offshore platform type may be most productive as a means to enabling future compensation mechanisms to be facilitated. However, until that point the data within this report provides a first glimpse into how kittiwakes utilise offshore structures in the North Sea and offers evidence that kittiwakes breed in significant numbers successfully to the benefit of the wider population on such offshore structures.

8 References

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Appendix D
Images of offshore breeding sites

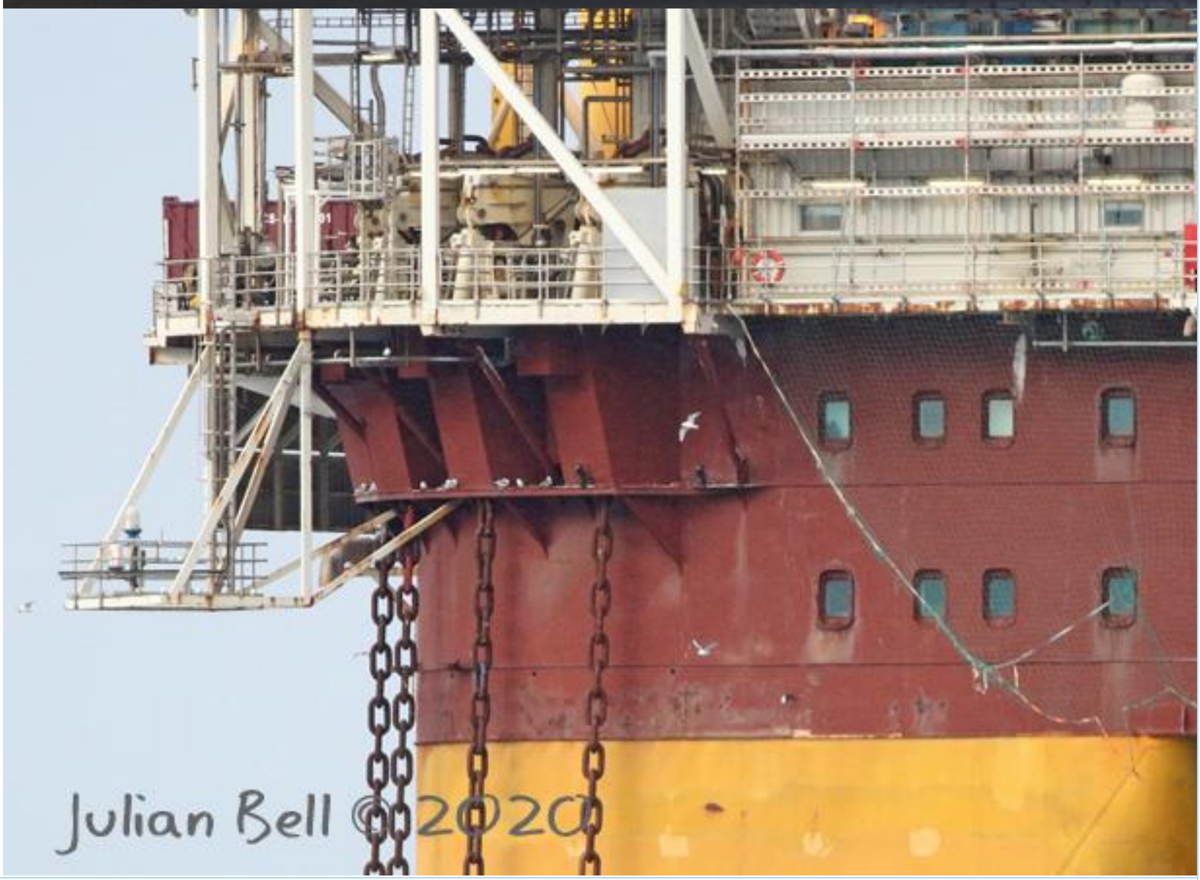
Norwegian platforms (source Christensen-Dalsgaard 2020)

Norwegian platforms (source Christensen-Dalsgaard 2020)

Figure 2. Examples of breeding localities on floating production storage and offloading unit, here on S
© *Supply Vessels* "Viking Lady" *and* "Chieftain Island"

Figure 3. Examples of Black-legged Kittiwake *Rissa tridactyla* breeding localities on a fixed concrete rig, he
Heidrun. © *Eldar Myrene* (left) and *Signe Christensen-Dalsgaard* (right)


ÅSGARD 'B'
6506/12 EQUINOR
Julian Bell © 2020


Julian Bell © 2020

Dutch Platforms (Camphuysen 2005)

Figuur 2. Adulte en juveniele Drieteenmeeuwen op nestrichels platform K15
1, 21 juli 2010. *Adult and juvenile Black-legged Kittiwakes on nests at plat*
K15-FC-1, 21 July 2010 (G.O. Keijl).

UK- Morecambe Gas Platform

See images online at
https://www.flickr.com/photos/21913923@N03/35452238000/in/photostream/

Wenlock Platform

UK- Sizewell - onshore


DANGER
KEEP OFF
SAFETY

Appendix E
Additional maps

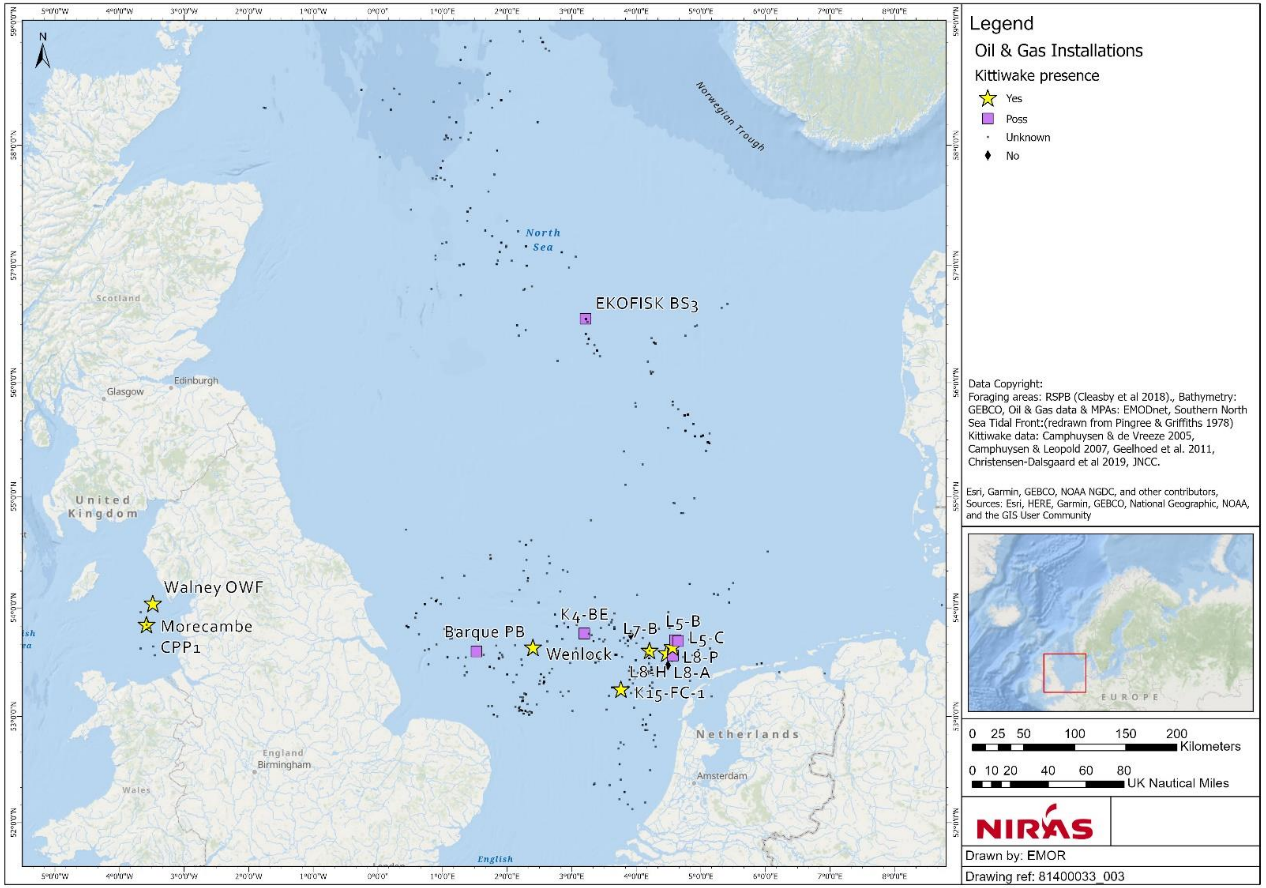


Figure E 1: Known and potential locations of breeding kittiwakes on offshore installations in the North and Irish Seas (excluding 2021 offshore survey data).

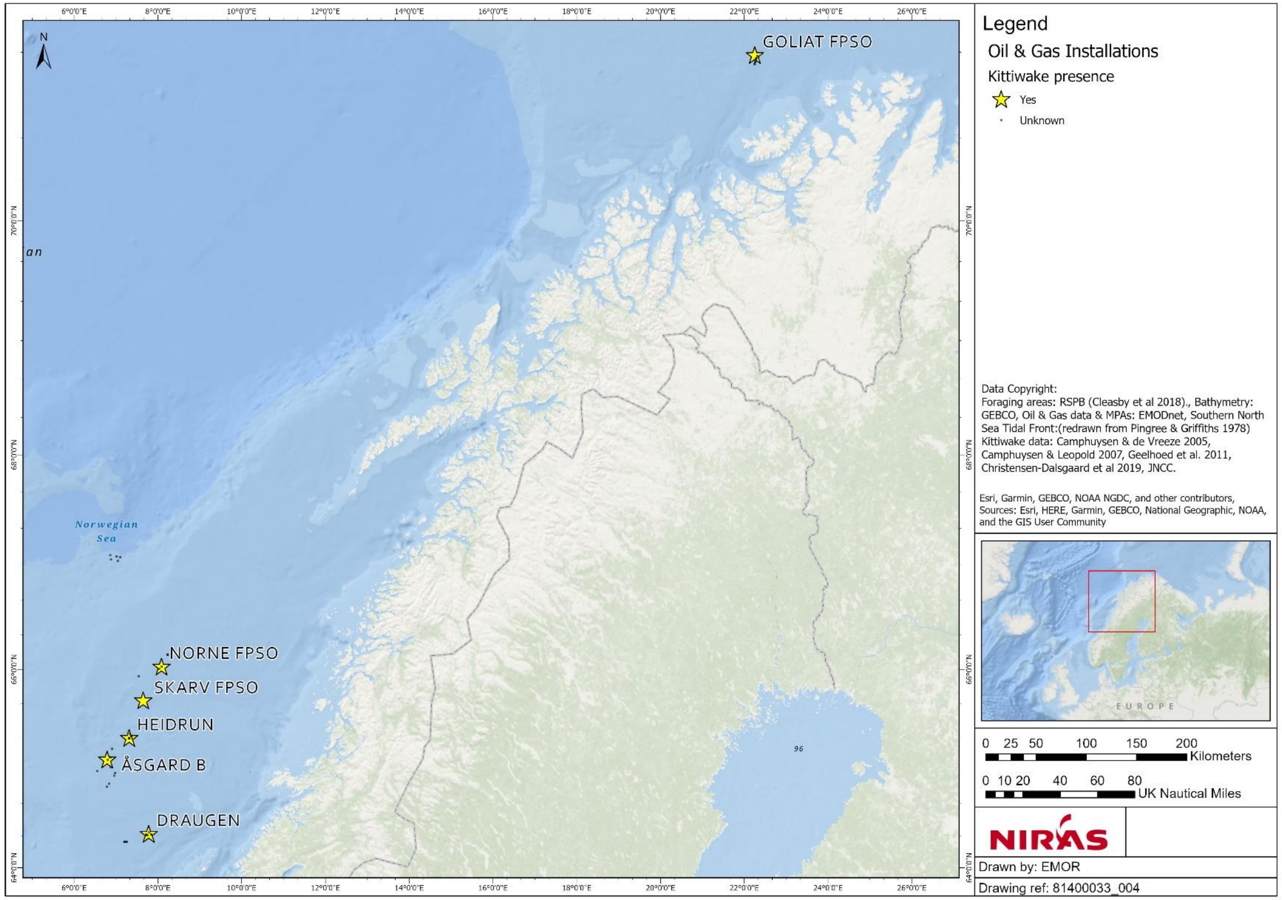


Figure E 2: Known and potential locations of breeding kittiwakes on offshore installations in Norway, adapted from Christensen-Dalsgaard *et al.* 2019.

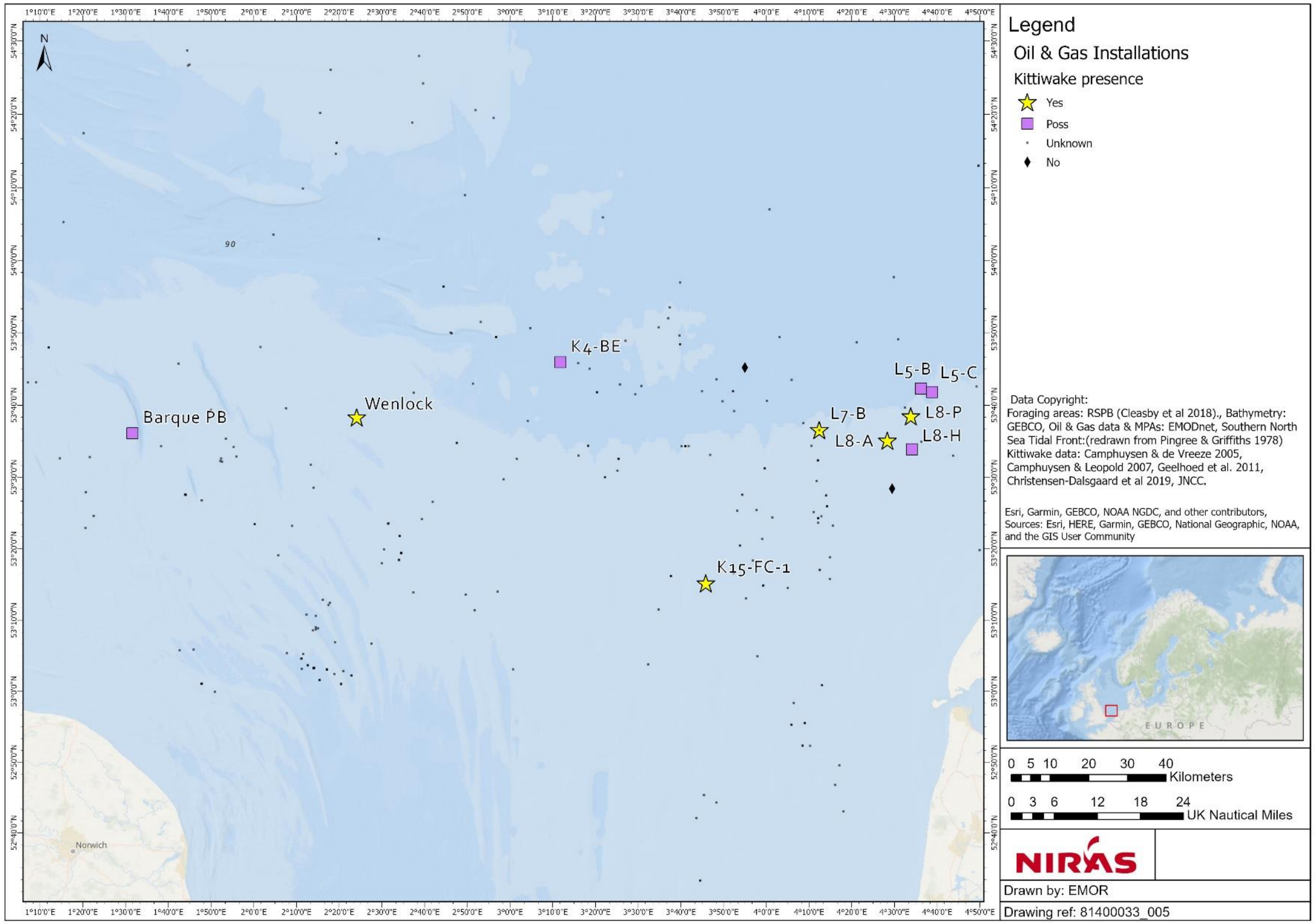


Figure E 3: Known and potential locations of breeding kittiwakes on offshore installations in the southern North Sea (excluding 2021 survey data).

Appendix F

Population modelling of black-legged kittiwake on the English east coast to identify the population of first time breeders available to recruit to new colonies.

1 Introduction

1.1 Background

1.1.1.1 Orsted Hornsea Project Four Limited (hereafter the 'Applicant') is proposing to develop Hornsea Project Four Offshore Wind Farm (hereafter 'Hornsea Four'). Hornsea Four will be located approximately 69 km offshore the East Riding of Yorkshire in the Southern North Sea and will be the fourth project to be developed in the former Hornsea Zone. Hornsea Four will include both offshore and onshore infrastructure including an offshore generating station (wind farm), export cables to landfall, and connection to the electricity transmission network. Detailed information on the project design can be found in **Volume A1, Chapter 1: Project Description**, with detailed information on the site selection process and consideration of alternatives described in **Volume A1, Chapter 3: Site Selection and Consideration of Alternatives**.

1.1.1.2 The Hornsea Four Agreement for Lease (AfL) area was 846 km^2 at the Scoping phase of project development. In the spirit of keeping within Hornsea Four's approach to Proportionate Environmental Impact Assessment (EIA), the project has given due consideration to the size and location (within the existing AfL area) of the final project that is being taken forward to Development Consent Order (DCO) application. This consideration is captured internally as the "Developable Area Process", which includes Physical, Biological and Human constraints in refining the developable area, balancing consenting and commercial considerations with technical feasibility for construction.

1.1.1.3 The combination of Hornsea Four's Proportionality in EIA and Developable Area Process has resulted in a marked reduction in the array area taken forward at the point of DCO application. Hornsea Four adopted a major site reduction from the array area presented at Scoping (846 km^2) to the Preliminary Environmental Information Report (PEIR) boundary (600 km^2), with a further reduction adopted for the Environmental Statement (ES) and DCO application (486 km^2) due to the results of the PEIR, technical considerations and stakeholder feedback. The evolution of the Hornsea Four Order Limits is detailed in **Volume A1, Chapter 3: Site Selection and Consideration of Alternatives** and **Volume A4, Annex 3.2: Selection and Refinement of the Offshore Infrastructure**.

1.1.1.4 The Applicant is submitting an application for a DCO to the Planning Inspectorate (PINS), supported by a range of plans and documents including an ES which sets out the results of the EIA. The Applicant is also submitting a Report to Inform Appropriate Assessment (RIAA) (**B2.2: Report to Inform Appropriate Assessment**) which sets out the information necessary for the competent authority to undertake a Habitats Regulations Assessment (HRA) to determine if there is any Adverse Effect on Integrity (AEoI) on the national site network.

1.1.1.5 This document has been prepared to support the identification of compensatory measures for Hornsea Four and its potential impacts on black-legged kittiwake (hereafter kittiwake). In light of the conclusions of the report to inform the appropriate assessment which will support the Hornsea Four DCO application, Hornsea Four's position is that no adverse effect on the integrity on the Flamborough and Filey Coast SPA will arise from Hornsea Four alone or in-combination with other plans or projects. Nevertheless, in light of the Secretary of

State's clear direction in his decision letter for Hornsea Three, Hornsea Four's DCO application will be accompanied by a derogation case (including compensatory measures) which will be provided on a "without prejudice" basis i.e., the derogation case will be provided without prejudice to Hornsea Four's conclusion that no adverse effect on integrity will arise.

1.1.1.6 This document presents work undertaken by DMP Stats and the British Trust for Ornithology (BTO) to investigate the number of black-legged kittiwake (Rissa tridactyla - kittiwake hereafter) potentially available from east coast English colonies to recruit to artificial structures offered as without prejudice compensation by Hornsea Four.

1.1.1.7 This document also presents Investigations into the reduction of sand-eel fishing effort included in the MMO consultation[12] on proposed fisheries management measures at Dogger Bank SAC and that builds on previous work (refer DMP Statistical Solutions, 2020). This was to estimate the possible effect of the proposed measures on kittiwake productivity to provide context regarding future possible productivity levels for proposed compensation measures.

1.2 Potential to recruit introduction

1.2.1.1 The following outlines the approach taken to estimate the numbers of potential recruits and summarises the findings:

- A range of simulations were conducted looking at the flux of chicks from their natal colonies to potential breeding at other locations, covering philopatry and standard PVA uncertainties.
- Three different philopatry rates were considered (low, medium, high) over eight kittiwake SPA colonies within broad influence of the Hornsea Four development.
- Population viability analyses (PVA) were conducted for each colony to determine numbers of potential recruits over a 35-year window. The end fate (death or allopatric breeding) of recruits was determined by annual survivorship estimates, and uncertainty from PVAs and survivorship was propagated through all calculations, along with varying philopatry levels.
- There are large numbers of recruits achieving breeding age annually under any of the philopatry scenarios. For example, 2030 alone generates approximately 28,000 (11,000 – 55,000[13]) for low philopatry, to 8,700 (3,400 – 17,000) for high philopatry. The Flamborough SPA alone is estimated to contribute approximately 11,000 (4,700 – 20,100) to 3,300 (1,600– 6,200) potential allopatric breeders in that year.
- There is little firm information about how allopatric breeders distribute themselves spatially, with spatial predictions of numbers being dependent on this component. Ringing studies and foraging ranges offer avenues, but substantive uncertainties that make them an unreliable basis for extrapolation.
- Based on ring recoveries during the breeding season from re-trapped live adult birds at age of first breeding, there is evidence that allopatric breeders distribute themselves coastally[14]

[12] Formal Consultation - MMO management of fishing in marine protected areas - Defra - Citizen Space
[13] Bracketed figures are 95% prediction intervals.
[14] As there is no re-sighting effort offshore, we do not know whether they would show this preference were there to be a proportionate sampling effort.

at large distances from their natal colonies e.g., 44% of such birds were re-trapped >100km from their natal colonies.

- Many assumptions and sensitivities would currently be required to estimate the number of allopatric breeders to a speculative platform. Principally:
    - Philopatry rates.
    - Recruit survivorship rates.
    - Nesting platform locations.
    - Biases in locations of ring recoveries if used for distribution maps.
    - Distribution to sea-based platforms is similar to observed distributions along the coast.
    - The area over which a potential nesting location may attract local nesters e.g., nesters are attracted within some distance of the platform.
- An example distribution of allopatric breeders is given based on ring recoveries, along with simulated sea-based nesting platform in near proximity of the Hornsea Four development. Under this construction, or any distribution of breeders as a decreasing function of distance from natal colony, new nesting developments would benefit from being nearer larger colonies.
- No defensible predictions of numbers to this example platform are possible but ringing and PVAs suggest that annually 100s to 1000s birds from Flamborough alone would be found farther coastally than this example platform at age of first breeding.
- While predictions of numbers of allopatric breeders to new nesting platforms is beyond current science, their relative attractiveness might be estimated under mild assumptions. Decisions on siting nesting platforms could be addressed by prey distribution maps and relative distributions of allopatric breeders, albeit not providing estimates of absolute numbers.
- Works here do not establish whether nests are a limiting factor for the extant colonies but seek to estimate the flux of recruits from natal colonies who would nest elsewhere. These may be currently non-breeding individuals that would benefit from additional nesting, or those who would have bred regardless. In the latter case, breeders at new nesting platforms would be interpreted as a redistribution of extant breeding birds, rather than additional. Once recruited to a breeding colony, adult birds show a high degree of philopatry.

1.3 Sand-eel fisheries introduction

- Rudimentary calculations were conducted based on Carroll et al. (2017), and most recent SA1 stock assessments, to provide estimates of the increases in chick numbers associated with reduced fishing pressures on sandeels.
- A scenario was explored where 10% of the average sandeel catch for the Dogger Bank SAC was to remain unfished (approximately 13,000 tonnes per annum). This was based upon analysis of VMS and landings data to predict the change in effort associated with the current proposed MMO fisheries management measures[15]. Assuming this previously fished biomass were now available for seabirds, calculations and simulations were conducted

[15] Though the fisheries management measures are intended to protect benthic features, the sandeel fishery is proposed to be included as part of the management proposal. Formal Consultation - MMO management of fishing in marine protected areas - Defra - Citizen Space

relating this to implied increased kittiwake productivity from the relationships given in Carroll et al. (2017).

- The Carroll relationships are related to biomass and/or fishing mortality *F*, so speculative proportional reductions in fishing removals in simple biomass terms need to be put in context of stock size. The stock assessment models for SA1 were used to project forwards spawning stock biomasses (SSB), under 3 levels of recruitment (low, medium & high), given this is one of the primary sources of sandeel SSB variability.
- These simulated productivities formed a component of 20-year PVA projections for the Flamborough Head SPA – both with and without fisheries related productivity increases implied by the relationships given in Carroll et al. (2017).
- Recruitment levels were highly influential on population sizes – with low recruitments leading to highly probable decreases in colony size under current fishing pressures.
- Under any recruitment scenario, the number of adults in the colony would be approximately 10% higher on average in 2027, rising to 30% in 2037, for the reduced fishing scenario versus the status quo. There was substantial uncertainty, permitting plausible estimated differences of approximately half these figures.
- There are necessary assumptions and approximations underpinning these results, so should be treated tentatively. In particular, the reliability of stock projections, PVAs and the SSB to productivity relationship estimated within Carroll et al. (2017), although in all cases uncertainties have been broadly addressed.
- Presents the existing historic environment baseline established from desk studies and non-intrusive field surveys undertaken to date, and consultation; and
- Presents commitments identified for Hornsea Four which avoid or minimise harm to the historic environment.

2 Nesting

2.1.1.1 We estimate here the simple flux of potential breeders from their natal colonies, as an indication of the numbers of birds that might occupy nesting platforms beyond SPAs relevant to the Hornsea Four development. The process is outlined, with illustrative results presented for a nesting location.

2.2 General Approach

2.2.1.1 This comprises three main parts:

1. Estimation of the numbers of chicks from a colony that will migrate over time (**Section 2.2.2**).
2. Estimation of the number of these recruits that will reach breeding age (**Section 2.2.3**).
3. The distribution of surviving recruits of breeding age, as a function of distance from their natal colony (**Section 2.2.4**).

2.2.1.2 This would in effect provide a distribution map of potential recruiting breeders over time. Specific nesting locations can be considered thereafter. The implementation of each step is expanded in turn.

2.2.2 Estimation of recruit numbers

2.2.2.1 This is based on current PVA information and philopatry rates. The colonies considered, with reference to the Hornsea Four development are given in **Figure F 1**. The rationale for using Hornsea Four as a reference point is that development of additional nesting is assumed to be nearby.

2.2.2.2 Foraging ranges are used as an initial filter for determining the scope of SPAs for consideration. A "mean max" foraging range + two standard deviations is used about Hornsea Four. This provides eight kittiwake assemblages for further modelling.

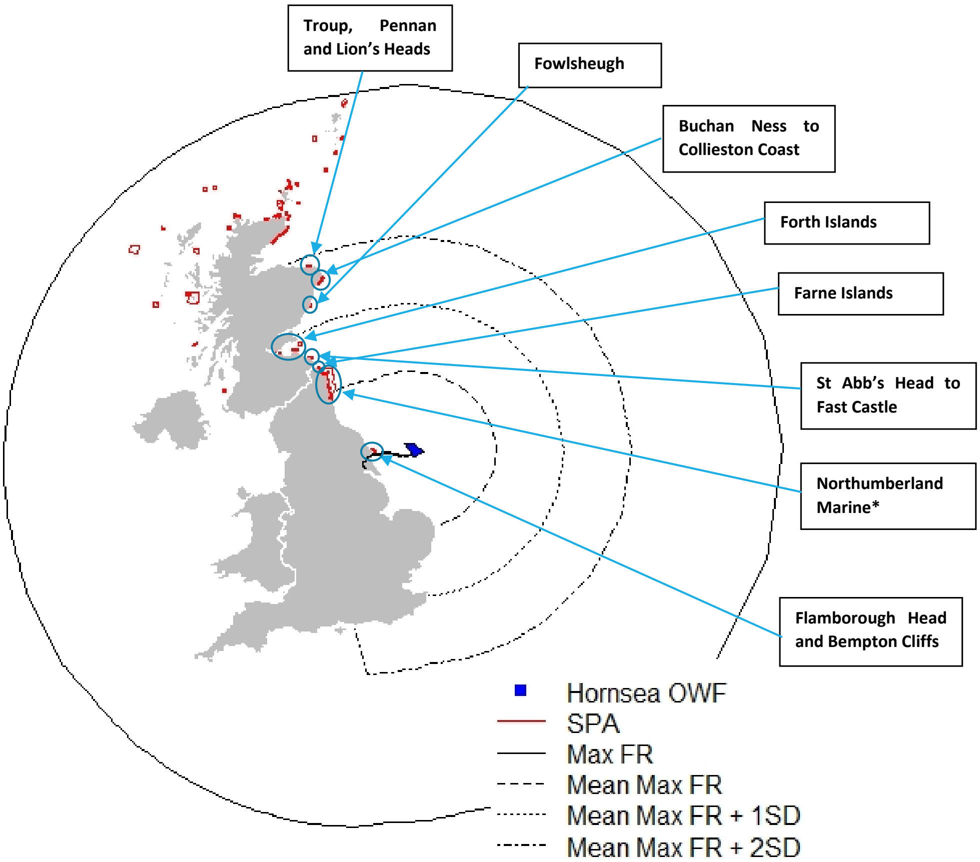


Figure F 1: Special Protection Areas within foraging range of Hornsea Four Offshore Wind Farm based on maximum foraging range, mean maximum foraging range, mean maximum foraging range + 1 standard deviation and mean maximum foraging range + 2 standard deviations from estimates in Woodward et al. (2020) (pers. comm. A. Cook).

2.2.2.3 The eight SPAs serve as the pool for recruiting breeders for any nesting development around Hornsea Four. The productivity for each SPA was projected forwards approximately 35 years using Population Viability Analysis (PVA) models (the NE nepva R package) – whose parameterisations are detailed in **Section 1** and further provided in an associated public github repository[16] detailing all code run. These are age-structured matrix projection models, providing numbers-at-age within colonies over time.

2.2.2.4 Philopatry rates are needed to determine levels of migration. There is substantive uncertainty about this, as detailed below, so rather than a single value three broad scenarios are considered – philopatry rates of 20% (low), 50% (medium) and 75% (high), which determines the numbers of chicks that will depart their natal colony before breeding. These are predicated on several sources of information outlined below.

2.2.2.5 Porter & Coulson (1987) report that on average 11% of each cohort of chicks recruit into the breeding population. However, this does not account for immature mortality and they also highlight variation in the age of first recruitment. Coulson and Coulson (2008) in a long-term study of kittiwakes at northeast England colonies concluded that it seems likely that philopatry never becomes a dominant characteristic of recruits to colonies in this species on balance, a conservative (in terms of potential recruiting breeders) value of 20% is adopted as a low philopatry rate.

2.2.2.6 Realistic estimates of the extent of philopatry in seabirds are notoriously difficult to obtain. Both survival and recapture or recovery probability need to be considered. As highlighted, Porter & Coulson (1987) doesn't account for survival. However, given the sampling effort at this site, assumptions that recapture probability is approximately 1 probably aren't too unreasonable but this isn't likely to be case elsewhere. It is also worth noting that these colonies were slightly atypical in that they are new and expanding and here might not behave in the same way as birds from elsewhere.

2.2.2.7 There are also challenges relating to site definitions. Some sites are very well defined, but others (e.g., Flamborough) less so. Given that we know young & "poor" quality birds are more likely to recruit to lower quality habitat at the edge of colonies, these may have different recapture probabilities, or may fall outside arbitrary site definitions (e.g. Aebischer and Coulson 1990).

2.2.2.8 Other figures as high as 77% rate have been reported (Coulson & Coulson, 2008) and recent ringing work (O'Hanlon et al., 2021) gives estimates of 66-73% (adult recaptures within 3km of natal colony), noting there are strong assumptions about the probability of a ring recovery conditional on distance from natal colony[17]. On balance, 75% is adopted as a high level of philopatry for later simulations.

2.2.2.9 A medium assumed level of philopatry is set at 50%, being roughly intermediate between the estimates from literature and ringing data.

[16] https://github.com/dmpstats/H4_compensation_PVA

[17] There is a very restrictive distribution of kittiwake ringers, colour-ring readers and a limited number of breeding sites where birds can be recaptured / re-sighted irrespective of personal availability. Therefore, it is noted that marked individuals are more likely to be recovered at their natal colony than surrounding colonies, especially if there is low resighting effort away from the natal colony (O'Hanlon et al. 2021). Even here, Hanlon's use of "especially" very much underplays the real-life scenario across the UK and away from Isle of May and less than a handful of other well watched volunteer/ professionally monitored colonies. Another important point raised by O'Hanlon et al. (2021) is how representative is the small number colonies from which we have rates of philopatry.

2.2.3 Recruit survivals

2.2.3.1 Survival of recruiting chicks to breeding age is required. This is based here on PVA survivorship information, so assumes year-upon-year recruit survivorship is similar to non-recruits. A product of survival proportions over juvenile classes gives an approximate survivorship of 49% to breeding age, with a standard deviation of 6.0%. This is applied stochastically via a normal distribution to the PVA chick projections.

2.2.4 Location of surviving recruits at breeding age

2.2.4.1 There are little firm data about where allopatric breeders will nest, and effectively none with regards artificial offshore locations[18]. Models of spatial distributions of allopatric breeders therefore must be based on coastal observations – a strong assumption that renders any predictions unreliable. Further, such coastal data has substantive uncertainty that complicates its use. An example follows based on ringing data which illustrates the sensitivity to these factors.

2.2.4.2 Ringing data presented in **Section 1.1** (O'Hanlon, 2021) might provide a basis for future locations of breeding age recruits. Here we use the re-trapping information as most pertinent and preferential, as being less prone to double-counting. The re-trap information here are for ringed chicks that are re-trapped alive as adults during breeding season. This indicates a high level of re-capture within 3km of the natal colony, without a marked distance relationship up to 1000km – each distance band beyond 3km has <10% of recoveries within each.

2.2.4.3 For simplicity, recoveries <3km from the natal colony are deemed not to be recruits, and the remaining birds appear within a distance band with roughly uniform probability. This implies decreasing densities of recruiting birds within distance bands, as the distance bands increase in size. The distance bands are projected about each SPA in **Figure F 2.**

[18] However, there is increasing evidence for where black-legged kittiwake have colonised artificial offshore structures (e.g. Christensen-Dalsgaard et al. 2020)

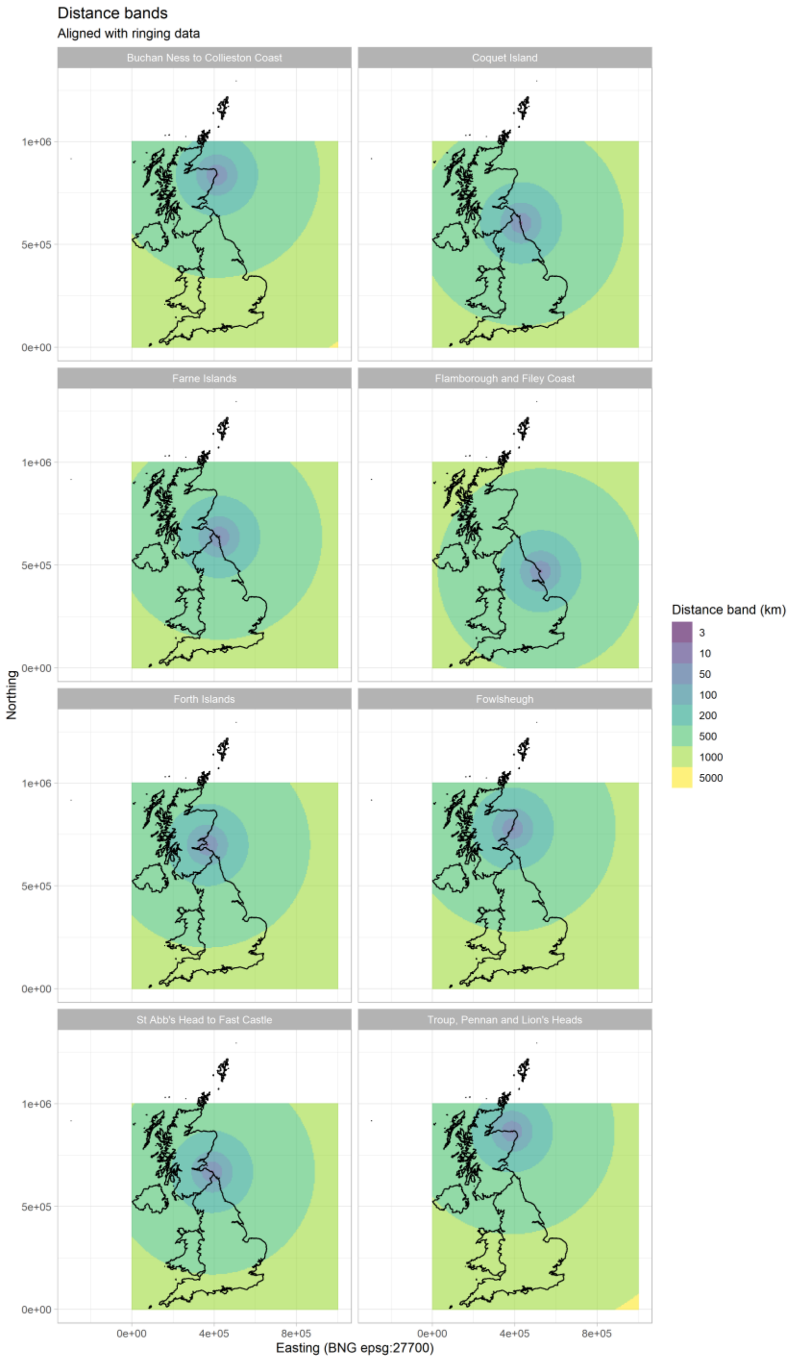


Figure F 2: Projections of distance bands around each SPA. Distance bands are aligned with ringing data given in Section 1.1 (O'Hanlon, 2021), and are labelled by upper bound e.g. 10 = between 3 and 10km.

2.2.4.4 An area encompassing much of the United Kingdom is considered at 5km resolution. The PVAs provide temporal projections for each SPA, which in turn provides projections for recruits successfully recruiting to breeding age. Coupled with distance distributions, each grid-cell has multiple simulated temporal projections of recruiting birds from each SPA.

Individual SPA contributions are presented in **Figure F 3**.

2.2.4.5 A simple summation of SPA contributions for a particular time and location provides a density of surviving recruits, assuming distance from natal colony was the sole determinant and follows a distribution similar to coastal ringing re-trapping data. An illustrative nesting site has been placed at 53.495N, 1.577E, as indicated by the white point in **Figure F 4.**

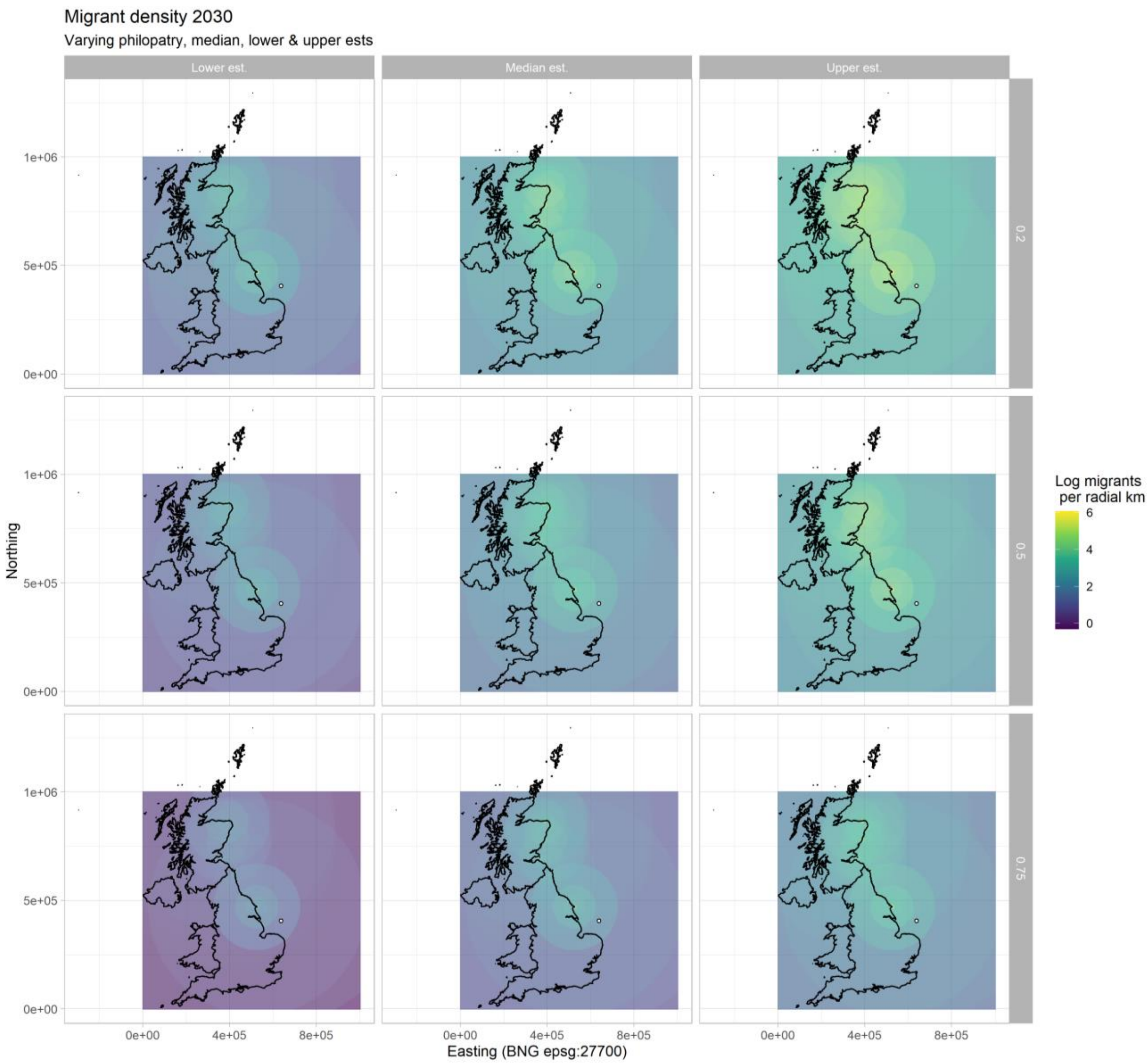


Figure F 3: Example aggregated numbers of breeding age recruits from the considered natal SPAs. Based on projections to year 2030, philopatry of 20% and presents median estimates with and upper 95% prediction intervals from simulations. Note log-scale for presentation. The white circle represents a speculative nesting platform, as expanded upon in later figures.

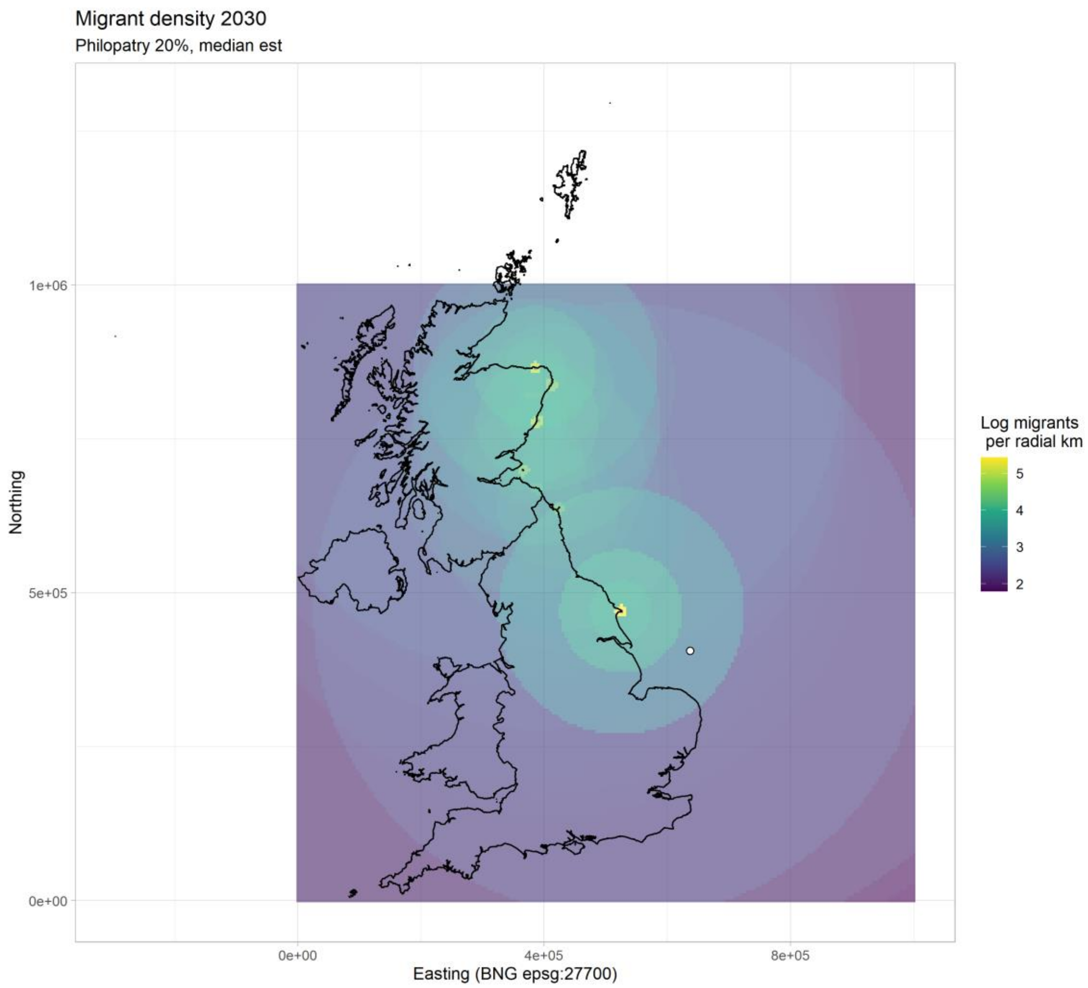


Figure F 4: example distribution of recruits from identified SPAs, assuming philopatry of 20% and distribution from natal colonies as a function of distance (informed by ringing data – O'Hanlon et al 2021 and Section 1.1. Note log scale for presentation purposes.

2.2.4.6 Results derived in this way are strongly dependent on the assumed distribution model – which is currently poorly understood. Subject to this however, new nesting platforms would have the largest pool of recruiting breeders when placed in areas of high predicted density – here effectively the distance to SPAs weighted by their population size.

2.2.4.7 Given the paucity of information, and sensitivity to assumption, detailed spatial predictions are not presented. However, coastal ringing data suggests the distribution of allopatric breeders is a decreasing function of distance from natal colony. This also is likely to be a component of attractiveness of offshore nest sites.

2.2.4.8 While no firm predictions are possible, ringing estimates place 40% recruits >200km from their natal colony at age of first breeding. Combined with PVA projections for Flamborough alone, this suggests several 100s to 1000s of allopatric breeders will annually find coastal nesting sites farther from their natal colony than speculative platforms in this area. For example, year 2030 provides median estimates of 1,300 – 4,300 (high/low philopatry) recruits being >200km from their natal Flamborough at age of first breeding.

2.3 Results

2.3.1.1 There is substantial variance about the numbers of recruiting breeders, as a product of PVA and survivorship uncertainties (**Figure F 5**). The philopatry rates are influential, as these are effectively multipliers, differing in size by a factor of 3.5 between low and high scenarios. The largest SPA colonies are predicted to produce several thousand recruiting breeders annually, regardless of philopatry rate e.g., Flamborough Head ranges from >1000 in the most conservative prediction to >20,000. This range falls to several 10s to 100s for the smallest (Coquet Island). Notably, several SPA are modelled to be in decline, including the largest assemblage at Flamborough.

2.3.1.2 The pool of recruiting breeders is given in detail for year 2030 in **Table F 1**.

Table F 1: PVA projections for year 2030 giving the numbers of recruits having survived to breeding age under 3 levels of philopatry.

SPA	Philopatry rate	Lower	Median	Upper
Buchan Ness to Collieston Coast	0.2	376	2237	5562
	0.5	249	1373	3404
	0.75	124	690	1687
Coquet Island	0.2	121	253	414
	0.5	73	159	266
	0.75	36	79	132
Farne Islands	0.2	528	1634	3484
	0.5	317	1036	2188
	0.75	160	518	1103
Flamborough	0.2	4715	10799	20091
	0.5	2890	6681	11992
	0.75	1552	3317	6236
Forth Islands	0.2	639	2266	4895
	0.5	416	1397	3068
	0.75	202	709	1527
Fowlsheugh	0.2	1305	4154	8689
	0.5	803	2574	5488
	0.75	404	1270	2697
St Abb's Head to Fast Castle	0.2	193	979	2342
	0.5	121	610	1468
	0.75	60	304	754

SPA	Philopatry rate	Lower	Median	Upper
Troup, Pennan and Lion's Heads	0.2	2984	5886	9771
	0.5	1899	3644	5973
	0.75	942	1844	3041

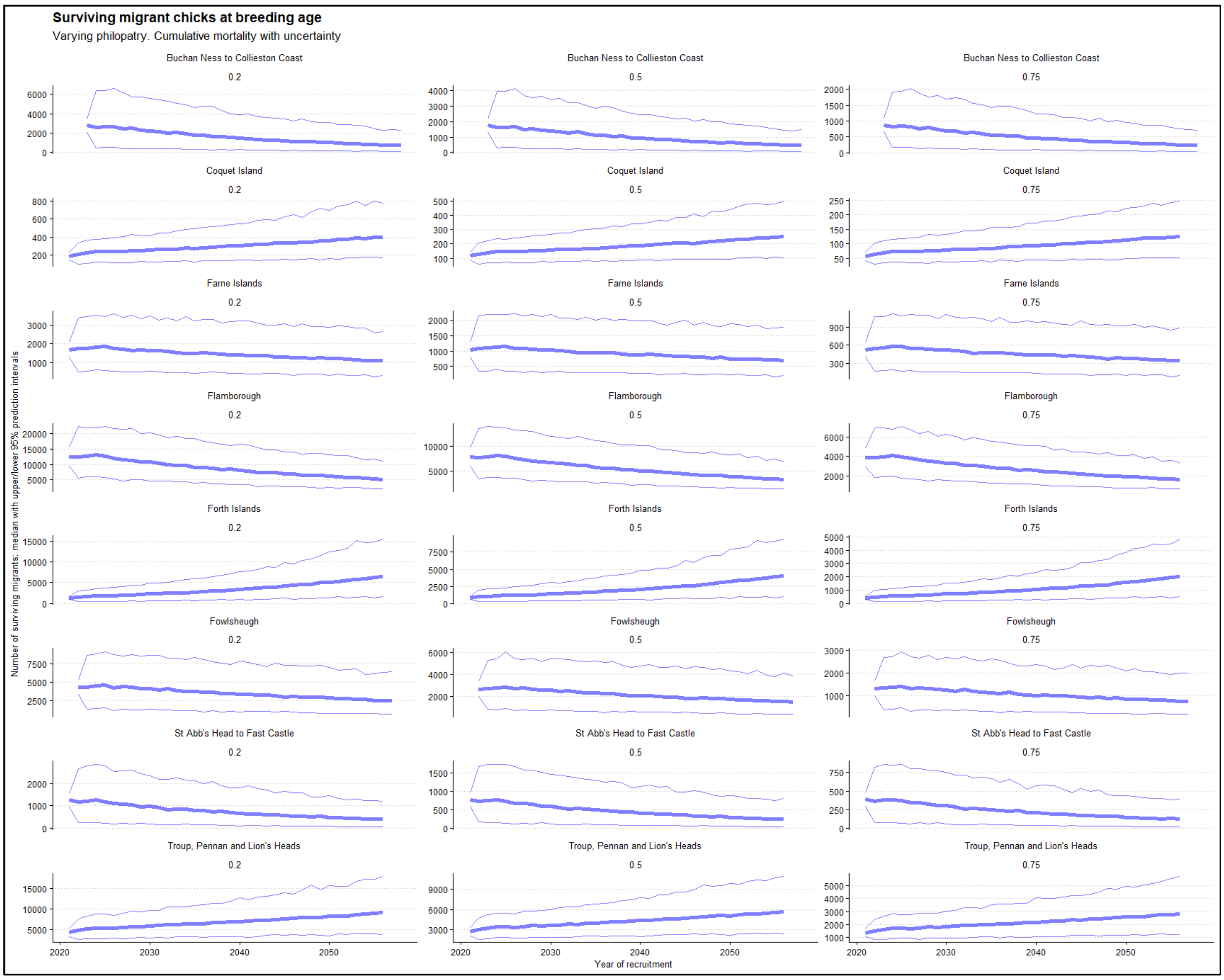


Figure F 5: Projections of the annual numbers of recruits successfully reaching breeding age, for each of the 8 SPAs and 3 philopatry rates. The bold line indicates median values, with a 95% prediction envelope.

2.4 Discussion

2.4.1.1 Estimates presented here are indicative of the numbers of recruits that survive to breeding age beyond their natal colony, and adopters of artificial nesting sites would draw from this pool. The approach is simple and depends on a range of assumptions, which are provided within the later caveats. Although there is substantive uncertainty, there are broad conclusions that can be drawn.

2.4.1.2 There is an annual flux of many thousands of recruits who survive to breeding age, at substantive distances from their natal colony. This spatial distribution is predicated on ringing re-trapping, which despite the number of potential biases, does indicate a substantive proportion of allopatric breeding over wide distances. Under the strong assumption that nesting preferences along the coast would reflect that of offshore platforms, then sites within some 10s of kilometres of large kittiwake colonies would be in purview of large numbers of recruits annually. Whether this is increasing numbers of breeders through nest availability, or a redistribution of extant breeders is subject to debate and not resolvable with the simple analysis here.

2.5 Caveats

2.5.1.1 There are substantive assumptions, sensitivities and semi-qualitative decisions underpinning the estimates presented. Some are considered here, with some consideration of their importance against the broad conclusions drawn.

2.5.1.2 The PVA's demographic parameters and uncertainties are assumed broadly correct. The forwards projections assume the starting states be broadly correct and there are no marked alterations over time. These are standard assumptions for PVAs, widely used. Relating to this, additional mortalities from extant or proposed windfarms have not been included in models at this point. These could be collated from EIAs (time-specific with development phases) of all known windfarms within the purview of the population studied here, with weighted apportioning based on foraging distances to kittiwake assemblages.

2.5.1.3 Philopatry rates have been modelled over a range of values to assess sensitivity. So, while not well established, results here reflect this uncertainty.

2.5.1.4 A major unknown is the attractiveness of new offshore nests. Here we assume similarity to coastal sites, so can be discussed simply in terms of distance from natal colony, as informed by coastal data. Dispersal distances (distance from natal colony for future breeding) are inferred from ring recoveries, hence subject to potential biases. Biases here might be severe, as conditional probability of ring recovery at the various distances and classes (dead/re-sight/re-trap) isn't known for this report but is unlikely to be constant. Errors here would be reflected in the spatial distribution of recruiting breeders. A general bias would not affect this, as it is their relative magnitude within distances that is important, but distance-specific biases would lead to under/overestimates. For example, lower conditional ring recovery at long distances would produce over-estimates near colonies, with corresponding under-estimates at distance.

3 Sand-eel fisheries

3.1.1.1 There are established links between the productivity of kittiwakes and the availability of sandeels, being one of their primary prey species (e.g., Frederiksen et al. 2004, 2005, 2007; Furness & Tasker 2000). Presented here are two investigations with respect to kittiwake assemblages in proximity to the Hornsea Four OWF development, and sandeels in the surrounding seas. The first part is a general review of relevant literature and data for this area and the link between birds and prey. The second looks at crude estimation of the effects of reduced fishing mortality in the SA1 area, on the FFC kittiwake population projected forwards 35 years.

3.2 Sandeel fisheries on the UK East Coast

3.2.1.1 Fisheries can affect seabird populations in several ways, either directly, as being caught in fishing gear and though provision of discards eaten by scavenging seabirds, or indirectly though influences on the fish community composition. The indirect effect of fisheries though reduction of prey species has been linked to breeding failures and reduction in breeding success in birds (Furness et al. 2013). There is a broad consensus that seabird breeding numbers are particularly affected by amount of food available, and that this factor is the single most important influence on seabird population sizes at a regional level (e.g. Cury et al. 2011). Therefore, changes in breeding numbers of seabirds resulting from changes in fish abundance can be dramatic (Mitchell et al. 2004).

3.2.1.2 Although there are many examples of seabird breeding success relating to pelagic fish abundance, there is often dispute as to how much the abundance of pelagic fish is determined by fishing, and how much variation is due to natural factors. The fishing of lesser sandeel (Ammodytes marinus) has been correlated with low and variable black legged kittiwake (Risa tridactyla) breeding success and reduced adult survival (Frederiksen et al. 2004, Scott et al. 2006). Furness et al. (2013) indicates that the single most important factor for productivity and survival of kittiwakes that could be managed, appears to be food supply and especially abundance of sandeel - the main diet of breeding kittiwakes at almost all UK colonies. The sandeel is also the target of the largest single-species fishery in the North Sea, and the impact on the industrial fishing on seabird populations has been a major conservation and fisheries issue (Furness 2002).

3.2.1.3 Sandeel in the North Sea can be divided into several broadly isolated reproductive sub-populations, with differing exploitation levels. An industrial adult sandeel fishery was in operation in the Firth of Forth from 1990 to 1999 (ICES area 4 in **Figure F 6**), being closed in 2000 except for a small amount of scientific catch until 2004 (Scott et al 2006). However, ICES areas (SA), 1r, 2r and 3r and 4 are currently intensely fished with variable amount of catches (**Figure F 7**), with SA 1r containing the productive Dogger Bank fishing area. There are large differences in the regional patterns of the catches.

3.2.1.4 SAs 1r and 3r have consistently been the most important regarding sandeel catches, although the fishery in SA 3r has varied over time, primarily from of changes in regulations and very low abundance of sandeel on the northern fishing grounds. On average, these areas together have contributed ~75% of the total sandeel catches in the period since

1983. The third most important area for the sandeel fishery is SA 2r, which has contributed on average approximately 17% of the total catch since 2003. SA 4 has contributed approximately 5% of the total catches since 1994, but there have been a few outstanding years with particular high catches, with 1994, 1996 and 2003 contributing 19, 17 and 20% of the total catches, respectively.

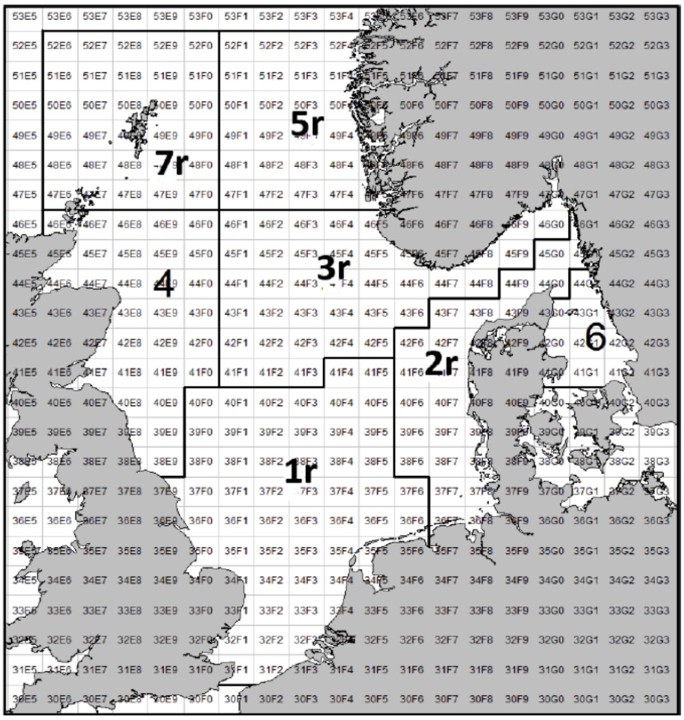


Figure F 6: Sandeel ICES division and management areas. Extracted from ICES (2019).

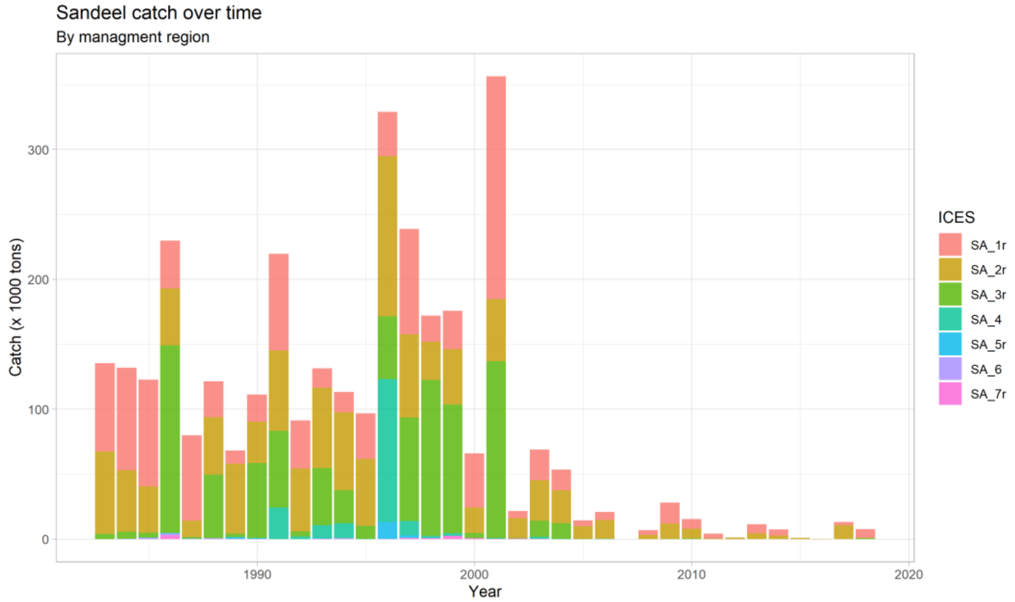


Figure F 7: Historical catches of sandeel across ICES management areas. Data extracted from ICES 2019.

3.2.1.5 Although it has been demonstrated that fishing has a strong effect on kittiwake demographics (Frederiksen et al. 2004), the exact mechanisms are unclear as kittiwakes and fishermen target different sandeel age groups. Adult kittiwakes eat mostly adults (1+ age group) during April and May but switch to juveniles (0 year group) for both themselves and their young in June July (Harris & Wanless, 1997). On the other hand, fisheries mostly targeted 3+ and 4+ age groups (ICES 2019). One possible explanation proposed in Frederiksen et al. (2004) is that sandeel recruitment is reduced in warm winters, as sea surface temperature was associated with kittiwake survival and breeding success. Therefore, the effect of fishing on breeding success in kittiwakes is not direct, as prevailing oceanographic conditions during reproduction may influence prey availability and hence breeding success, by directly influencing sandeel recruitment (Daunt et al. 2008). **Table F 2** synthesises the effect of fishing in demographic performance of kittiwakes.

Table F 2: Review of the influence of fishing in the Kittiwakes colonies in the North Sea. CPUE refers to the sandeels capture per unit of effort, SST is the sea surface temperature, NAO is the North Atlantic Oscillation.

Reference	Data extension	Area	Model	Response Variable	Covariates	Management advice	Main Drawbacks	Main Conclusions
Rindorf et al. 2000	1986-1998	Demographic data from the Isla of May. Fisheries data from the Wee bank	Simple linear model	Breeding success	Standardized CPUE from Jun and May/Jun	Fisheries influence breeding success	The use of CPUE as availability index	Kittiwakes breeding success is positively related with Jun Sandeels CPUE, but negatively related with May/Jun CPUE.
Frederiksen et al. 2004	1986-2002	Demographic data from the Isle of May. Fisheries data from the Wee bank	Deterministic and stochastic matrix model with 15 age classes	Breeding success, survival, population abundance, population growth rate	NAO index, Sandeels CPUE, winter SST, presence/absence of fishery	Closure of commercial sandeels commercial fishing.	Insufficient data to estimate all parameters within the matrix model. The use of CPUE as sandeels abundance index	Low performance in kittiwakes is related with high winter SST and the presence of industrial fishing. Mechanism on how fishing affects kittiwakes population are unknown.
Scott et al 2006	1985-2003	Demographic data from the Isla of May. Fisheries data from the Firth of Forth	Simple linear Model	Breeding Success	Timing of the spring bloom in years with and without commercial fishing	NA	Oceanographic data should be treated as time series (e.g Arima) to avoid spurious results.	Breeding success is 0.33 (SE=0.05) in year without fishing that in years with fishing. Effect of climate alone explain 56% of the variance in B. success in years without fishing.
Daunt et al. 2008	1996-2003	Scotland, around Isla of May, Wee bank (ICES Boxes 41E7, 41E8)	Bioenergetic model	Fish consumption breeding success	years with and without commercial fishing	Fishery closure should be considered as potential management option. The effectiveness of	Bioenergetic models fed on large number of parameters usually taken from different	Fisheries closure can have a beneficial impact on top predator, but environmental conditions before and after the closure are critically important.

Reference	Data extension	Area	Model	Response Variable	Covariates	Management advice	Main Drawbacks	Main Conclusions
						the closure will depend on environmental conditions	areas or different studies.	
Cook et al. 2014	1986-2010	29 colonies of kittiwakes along the North Sea.	Linear Mixed models	Two indicators of (i) abundance of seabirds at breeding colonies (ii) abundance of seabirds at breeding colonies,	SST (lagged), Total biomass of sandeels	Management measures to achieve targets, such as limiting fishing mortality.	Controversy still holds on the use of sea bird as biological indicators given plasticity (shift in diet) is not accounted.	SST (lagged) negative impact on breeding success. The breeding failure indicators and kittiwake breeding success indicator showed negative relationships with fisheries pressure.
Carroll et al. 2017	1986-2014	England, assessment area (S1) for Sandeels and Flamborough Head and Bempton Cliffs for kittiwakes data	Linear Mixed models	Breeding Success	Recruitment, Spawning biomass, Fishing Mortality (both lagged) and SST.	Precautionary approach for fisheries management. Spatial fisheries management and set limit for fishing mortality.	Uncertainty and correlation among fisheries times series is not taken into account	lower temperatures and fishing mortality were positively associated with sandeel bio-mass, and higher sandeel biomass and lower fishing mortality were positively associated with kittiwake productivity.

3.2.2 Relationships between kittiwake productivity and sandeels

3.2.2.1 The review in **Table F 2** reveals that breeding success is the demographic parameter most commonly explored in this context. The breeding season is the most energetically demanding part of the seabird life cycle, and a successful outcome is critically dependent on the availability of sufficient amount of high-quality food. In this context, Harris & Wanless (1997) concluded that poor breeding success in kittiwakes was correlated with a reduced proportion of 0-year group sandeel in the diet. In addition, Furness et al. (1999) found a significant and positive correlation of breeding success with the abundance of 1+ group sandeel stock in the North Sea. Work in Rindorf et al. (2000) appears as the first formal assessment of the effect of fishing in breeding success in the North Sea, using capture per unit of effort (CPUE) of the sandeel as a measurement of availability of food for kittiwakes. The main conclusion was that breeding success in kittiwakes was significantly reduced when sandeel availability to the fisheries in Jun was low.

3.2.2.2 Frederiksen & Wanless (2006) reviewed evidence from the closure of sandeel fisheries in the Wee Bank in 2000 and increased productivity of kittiwakes and other seabirds. They found clear evidence that the closure resulted in increased productivity of kittiwakes within the study area, compared with a control area outside the closure zone. These results agreed with the earlier findings of Frederiksen et al. (2004) that the sandeel fishery in this area reduced productivity of kittiwakes on the Isle of May during the years of the fishery. Productivity of kittiwakes did not differ between fishery and non-fishery years outside the closure zone, but inside the zone breeding productivity was considerably lower during fishery years (the difference being 0.28 chicks per nest). However, the analysis of productivity data for monitored colonies of other seabirds was based on much smaller sample sizes and showed less clear results due to chance variations. Frederiksen et al. (2004) concluded that poor breeding success of kittiwakes was associated with warm winters and the presence of a local sandeel fishery.

3.2.2.3 In a related investigation, Scott et al. (2008) studied the effect of kittiwakes breeding success with the timing of the spring bloom in the Isle of May, and in years with/without fishing. They concluded that breeding success of kittiwakes increased by 0.13 chicks per pair for every five days delay in timing of the spring bloom. Kittiwakes thus bred more successfully in the years when the spring bloom and stratification in either region occurred later, but the associated variability was considerable. There was evidence that breeding success was 0.66 chicks higher in years without fishing than in years with fishing. The final model containing both the effects of spring bloom date and the sandeel fishery explained 74% of the variance in breeding success. Separating years with or without a fishery, the effect of climate alone explained 56% of the variance in breeding success in years without a fishery and 10% of the variance in years with a fishery. This suggests that important climatic variables are more easily identified in the absence of the confounding effects of a fishery.

3.2.2.4 Daunt et al. (2008) also examined the effect of closure of the sandeel fishery around the Isle of May and whether this closure benefit the breeding success in seven seabird species including kittiwakes. The work in Daunt et al (2008) confirmed previous studies cited above between kittiwakes breeding success and the abundance and availability and 0 and 1+ age group of sandeel. This study also confirmed that the environment and fishery are additive in influencing kittiwake breeding success. However, the precise mechanism linking breeding success to variations in sandeel abundance and fishing activity remains unclear. In addition, although fisheries closure can have a beneficial effect on breeding success of kittiwakes, environmental conditions before and after the closure are likely to be critically important.

3.2.2.5 Cook et al. (2014) developed two indicators to assess the state of nine seabird populations in the UK, including kittiwakes. The first indicator examined the annual variation in numbers of birds attending the breeding colonies and the second indicator was breeding failure. They investigated how sensitive each of these indicators was to the impacts of fishing. The breeding failure and breeding success indicators showed consistent negative relationships with fisheries pressure, represented by the interaction between sandeel population size and the proportion of the population harvested. Cook et al. (2014) reported that changes in species breeding failure rates were strongly correlated with pressure from fisheries.

3.2.2.6 In the studies cited, the effect of fishing is a categorical factor in the comparison of breeding success of kittiwakes in years with and without fishing. The work in Carroll et al. (2017) is a departure from these previous studies by proposing a model containing a continuous effect of fishing and sandeel biomass on the breeding success of kittiwakes. Carroll et al. (2017) proposed a mixed linear model in which the amount of breeding success is predicted by changes in sandeels recruitment, fishing mortality, spawning biomass and sea surface temperature, using different lags in all these covariates. They concluded that higher kittiwake breeding success was associated with higher sandeel spawning stock biomass the preceding winter and lower sandeel fishing mortality two years previously. In addition, higher sandeel spawning biomass was associated with lower temperatures and lower sandeel fishing mortality. Hence, lower temperatures and fishing mortality were positively associated with sandeel biomass, and higher sandeel biomass and lower fishing mortality were positively associated with kittiwake productivity.

3.2.3 Conclusions

3.2.3.1 Most of the reviewed studies on the relationship between fishing and breeding success have been based around the Isle of May. This area provides a unique natural laboratory to assess the effect of fishing before and after the closure of sandeel fisheries in 2000. Therefore, most of reviewed studies have focussed on the changes in breeding success in contrast years with and without fishing. All these studies reported that kittiwakes breeding success was higher in years with no fishing, and therefore, fishing is concluded to produce a deleterious effect on breeding success. However, mechanisms on how fishing affect breeding success remains largely unclear, although is known that oceanographic conditions before and after the fishing closure is likely to play a critical role in the observed variations of breeding success. Carroll et al. (2017) found that both lower sea surface temperatures and fishing mortality were positively associated with sandeel biomass, and higher sandeel biomass and lower fishing mortality were positively associated with kittiwake productivity at Flamborough and Filey Coast SPA. Therefore, there is a confounding effect between climate and fishing, meaning their relative contributions are difficult to entirely disentangle in exploration of breeding success variation.

3.2.3.2 As climate cannot be controlled, fishing is the natural management variable to enhance breeding success in kittiwakes. In this context, Carroll et al. (2017) proposed an approach to bird conservation, in which sandeel fishing is not necessarily closed, but managed, to provide sufficient food for increasing breeding success. This idea is promising in the sense that changes in sandeels population variables such as recruitment, spawning biomass can be controlled by fishing mortality and therefore can be a direct relation between fishing mortality (controlled by catches), and kittiwakes breeding success. Although this idea may be appealing for managers, it is problematic within general fishing theory. In particular, small pelagic fishes with few age classes such as the sandeel, show high variability in the recruitment and these variations are almost entirely driven by environmental conditions. In other words, in fishing stocks like sandeel in the North Sea which are managed, sustainable and not severely depleted, the control of fishing mortality is expected to have a small effect on recruitment and subsequent food available to enhance kittiwakes breeding success.

3.2.3.3 One practical option to prevent bird breeding failures from food loss to fisheries, is through a broader management strategy. In this context, Cury et al. (2011) proposed a general principle based in data from seven seabird ecosystems, named "one-third for the birds". This concept suggests that a third of the peak long term maximum stock size of foraged fish should be left for birds in each year to ensure that seabird population remains stable. This is a simple, empirically derived guiding principle that embraces the ecosystem approach to management aimed at sustaining the integrity of predator-prey interactions and marine food webs for the benefit of both natural predators and humans. Given the sandeel stock are assessed yearly with readily available integrated stock assessment models, it would be straightforward to estimate each year whether or not the "one-third for the birds" is achieved for kittiwake populations along the North Sea. This approach benefits from not being intimately tied to parameters with low precision.

3.3 Expected breeding success under reduced fishing pressure in SA1

3.3.1.1 Here we estimate the expected increase in breeding success of kittiwakes, under a scenario of reducing fishing mortality on the S1 sandeel stock assessment area. This reduction is considered over the period 2022 to 2026. The reduction in sandeel fishing effort is assumed to be approximately 10% from the region based upon VMS and landings data and the proposed Dogger Bank SAC fisheries management area in the recent MMO consultation[19], which has an average annual catch of 130,444 tonnes. An estimate of 10% is based on estimated take from the Dogger Bank 2014-2018 (Brown and May Marine Ltd) against ICES SAr1 stock assessments for the same period.

3.3.1.2 The approach here relies upon estimates from Carroll et al. (2017), stock projection models underpinned by ICES stock assessments for SA1, and population viability analysis (PVA) models for the Flamborough Head and Bempton Cliffs. As this relationship between kittiwake breeding success and sandeels is primarily a function of biomass, projected

[19] Formal Consultation - MMO management of fishing in marine protected areas - Defra - Citizen Space

changes in fishing mortality have to be expressed in these terms. This necessitates projections of the stock forwards in time. The population-level effects from these changes are established by PVA projections, with all their usual concomitant uncertainties simulated over.

3.3.1.3 These modelling elements are covered in turn.

3.4 Sandeel population projection

3.4.1.1 Population projection is a common procedure to evaluate the effect of fishing scenarios (e.g., changes in catches) on the population. In age-structured stock assessment models, as implemented for sandeels, projections can be done by simple exponential decay of a cohort.

3.4.1.2 Initial conditions of the population were taken from the last stock assessment available (ICES 2019) which provides the vector of abundance at ages (a) in the year *y* = 2019, (denoted N(a,*y*=2019)). Exponential decay of the abundance is assumed to be continuous and depending on the total mortality Z:

$$N(a+1, y+1) = N(a, y)\, exp[-Z(a, y)] \qquad y > 2019$$

3.4.1.3 where the a are discrete ages from 0 to 4, *y* is the year and Z is total mortality which represents the sum of fishing (F) and natural Mortality (M):

$$Z(a, y) = F(a, y) + M(a)$$

3.4.1.4 To estimate fishing mortality at age and years, a model based on the separability assumption was used as follows:

$$F(a, y) = S(a)F(y)$$

3.4.1.5 Where S(a) is the selectivity at age.

3.4.1.6 For each projected year, spawning biomass (SSB(*y*)) and the catch at age (C(a, *y*)) were estimated:

$$SSB(y) = \sum_a N(a, y)\, P(a) w(a)$$

$$C(a, y) = \frac{N(a, y) F(a, y)[1 - e^{-Z(a,y)}]}{Z(a, y)}$$

3.4.1.7 The latter being Baranov's catch equation, which is commonly used to compute catch from continuous fishing mortality.

3.4.1.8 The management strategy of sandeels in ICES considers one scenario based constant fishing mortality derived from status quo (ICES 2021). This means that the last fishing mortality estimated is used to project the abundance and estimate future catches. Fishing mortality of status quo has been estimated as Fsq=0.49 (1/year) for 2020 (ICES 2021). This will be referred to as the fishing status quo hereafter, against which fishing reduction scenarios are measured.

3.4.1.9 Recruitments for years 2020 and 2021 are taken from ICES (2021), and for forwards recruitment from 2022 to 2026, three different scenarios were implement based on percentiles of the available time series of recruitments. These were:

1. Low recruitment, the 25% percentile of historic recruitment,
2. Medium recruitment, the 50% percentile,
3. High recruitment, the 75% percentile.

3.4.1.10 Two scenarios for fishing mortality were implemented, one in which the status quo Fsq=0.46 is used across all projected years and other, using a reduction in fishing mortality of 10% less catch – hereafter the partial fishing mortality. The catch reductions are assumed from 2022 and effects on kittiwake populations are assessed through to 2026.

3.4.1.11 Note because recruitments and fishing mortality are constant and the sandeel population is composed only of 5 age classes, the stable age distribution is reached at 2026. This means that results for each recruitment scenario will be the same thereafter.

3.4.1.12 Table F 3 shows the values taken from the stock assessment 2019 (ICES 2019) which were used to implement the population projections. Some values such as weight at age and natural mortality were averaged between half-years, as they were informed on the stock assessment report.

Table F 3: Population parameters used on the population projections for sandeels. N indicates the abundance (x 10^6) from the stock assessment report 2019. Recruitments values for 2020 and 2021 were taken from ICES.

Age class	N (2019)	Maturity	Weight	Mortality (M)	Selectivity
0	107870	0.00	1.55	0.61	0.78
1	60357	0.02	5.30	0.52	1.00
2	2860	0.80	8.27	0.36	0.92
3	6562	0.99	10.82	0.30	0.92
4	519	1.00	12.83	0.28	0.89
Rec 2020	52641	**Rec 2021**	110664		
Rec Low	56338	**Rec Med**	112346	**Rec High**	205869

3.4.2 Sandeel biomass projections

3.4.2.1 Projections (Figure F 8) show that under a high recruitment scenario, the spawning biomass rapidly increases to the levels previously observed before 2000 (ICES 2019). Conversely, repeated low recruitments cause the spawning biomass to decrease over time. Assuming medium recruitment and Fsq, the population is maintained at the actual (2020) levels of spawning biomass. Given 10% less of catches accumulated other the period 2022-2026, partial fishing mortality naturally produces higher SSB in all three scenarios of recruitments.

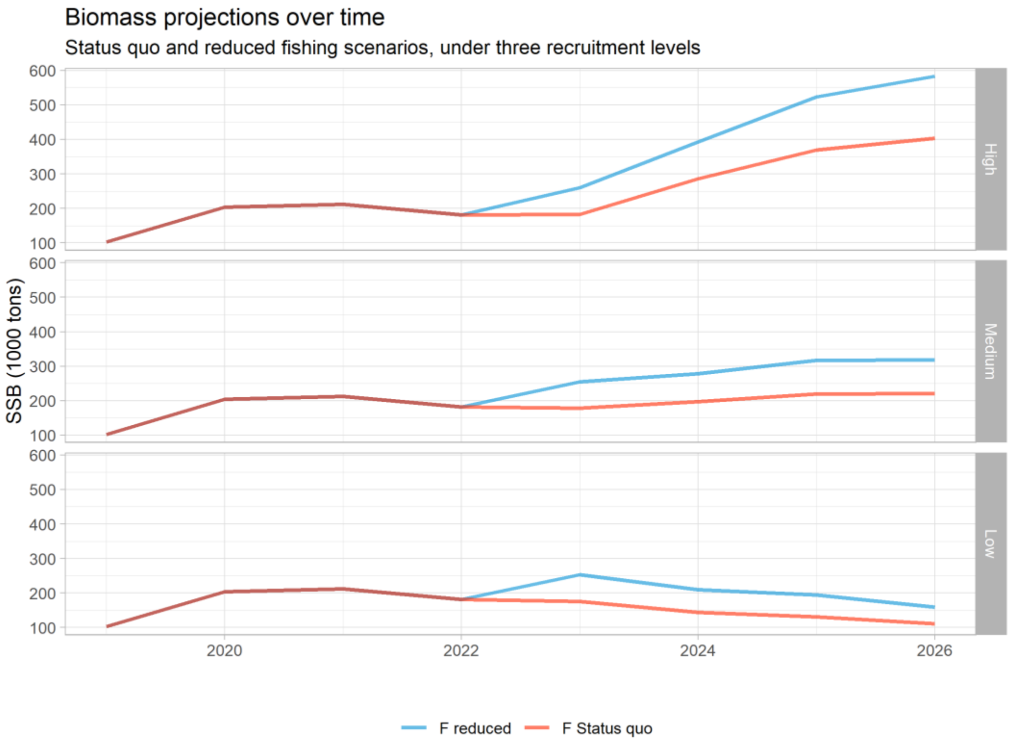


Figure F 8: Projections of the spawning biomass under three different levels of recruitments and assuming status quo fishing mortality and catch reduced 10%

3.4.2.2 Projected catches for 2026, as expected, increase with the greater recruitment and decrease with greater fishing mortality (**Figure F 9**). At high recruitment, catches can be approximately 300 thousand tonnes, which are similar pre-2000 catches. Medium values of recruitments will show values of catches of around 150 thousand tonnes, and low recruitment will produce catches of less than 100 thousand tonnes. Catches from the low recruitment scenario are notably similar to the catches recorded in the last five years (ICES 2019).

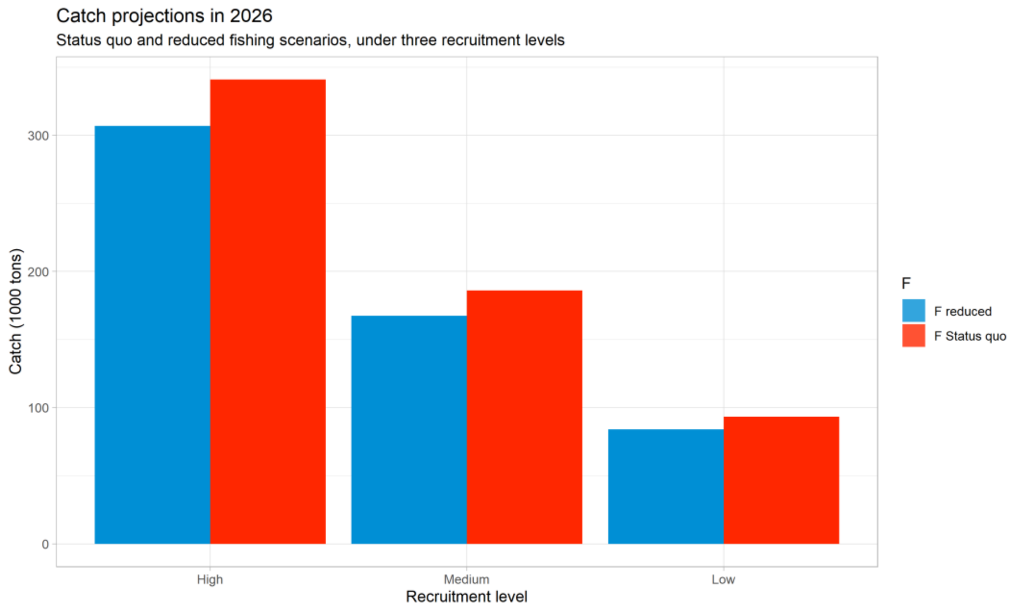


Figure F 9: Predicted catches for 2026 using different levels of constant recruitment (High, Medium, Low) and for total fishing mortality and partial fishing mortality (10% less catch from 2022)

3.4.3 Projections to kittiwake breeding success

3.4.3.1 Using the spawning biomass projected to 2026, it is possible to estimate changes in breeding success using Carroll et al's (2017) model (refer previous report – DMP, 2020). Given this positive relationship between breeding success and spawning biomasss, a high recruitment scenario also produces higher values of breeding success, versus the lower breeding success found with low recruitment (**Figure F 10**). The effect of fishing mortality is to reduce spawning biomass, providing the reduced breeding success levels seen in **Figure F 10.**

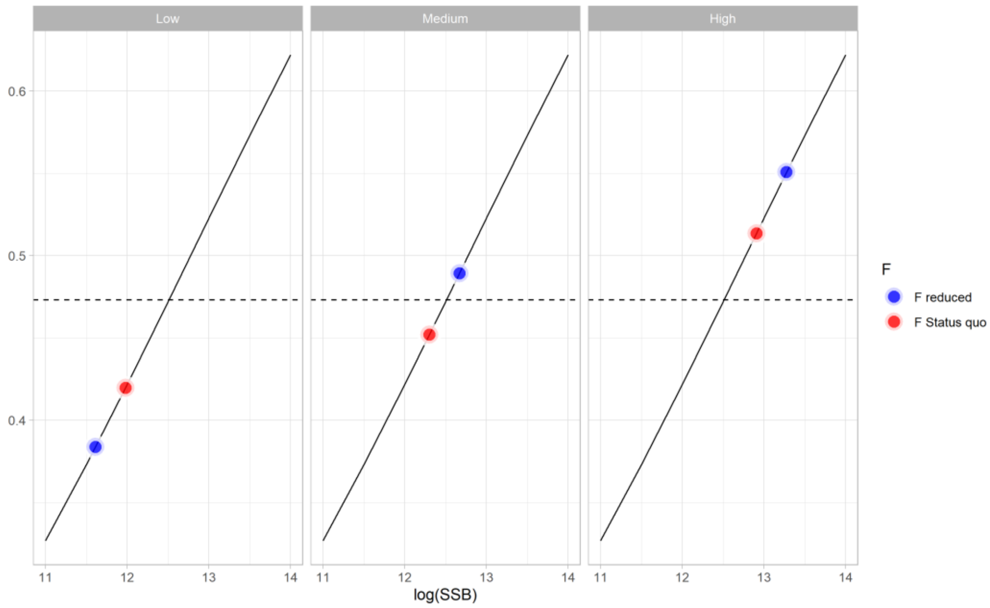


Figure F 10: Breeding success for 2026 using different levels of constant recruitments (High, Medium, Low) and for status quo mortality and reduced fishing mortality.

3.4.3.2 Uncertainty on breeding success across recruitment scenarios was incorporated via resampling from a normal distribution the slope ($\hat{\beta}_1$), and standard errors ($\hat{S}_{\hat{\beta}_1}$), for the relationship between breeding success and SSB reported in Carroll et al. (2017). The intercepts (or their standard error $\hat{S}_{\hat{\beta}_0}$) are not presented in Carroll et al. (2017) so are derived assuming proportionality with standard error of the slope $\hat{S}_{\hat{\beta}_1}$. Further, each $\beta_{1,j}$ are resampled with $\beta_{0,j}$ computed assuming a correlation between these two parameters $\hat{r}_{\hat{\beta}_0,\hat{\beta}_1} = -0.8$ and using a linear model described in Roa et al. (1999):

$$\beta_{0,j} = \hat{\beta}_0 + \hat{r}_{\hat{\beta}_0,\hat{\beta}_1}\left[\frac{\hat{S}_{\hat{\beta}_0}}{\hat{S}_{\hat{\beta}_1}}\right][\beta_{1,j} - \hat{\beta}_1]$$

3.4.3.3 The 95% confidence interval of breeding success on each recruitment and fishing mortality scenarios were computed using the percentile method based on 10,000 iterations.

3.4.3.4 Partial fishing mortality produces differences between 9% and 7% in the extra (delta) breeding success depending on the recruitment scenario (Table F 4). A high recruitment scenario will produce lower differences in breeding success between fishing mortalities - vice versa for low recruitment. This is responding to the relationship of breeding success and SSB from Carroll et al. (2017) which is in log scales for SSB. This means that at low levels of recruitment, variations in SSB produces bigger differences in breeding success. Depending on the numbers of nest in the colony and recruitment scenarios, Table F 2 shows a net difference in breeding success of between 2511 and 3347 chicks in 2026, given a reduction in 10% of catches expected in 2026.

3.4.3.5 Several assumptions are made, in particular:

- Speculated decreased catches in the Dogger Bank are not compensated for by increased catches elsewhere within the S1 sandeels stock assessment area.
- Uncertainty on breeding success is only partially assessed. Stock assessment modelling code was not available, so SSB estimates are lack error.
- Status quo projections are based on constant fishing mortality as the management strategy. In the event ICES advice changes in following years, the status quo projections will not hold, along with concomitant breeding success estimates. Note that for ICES 2021, management advice is for fishing mortality of MSY of escapement, which is much smaller (F=0.022) than used here. However, the status quo F is the most likely management decision, as per the last available stock assessment.
- Results are based on the idea of constant selectivity. For example, if different fleets fish the S1 area, or current fleets change gear or operations, results may also change.

Table F 4: Estimated spawning biomass (SSB), breeding success (θ) with status quo fishing mortality (1) and partial fishing mortality (2), for different levels of recruitment, and number of nests in a speculative colony. Results evaluated for 2026. Bracketed figures give the 95% confidence intervals for breeding success on a per breeder basis.

RECRUITMENT		VALUE	NUMBER OF NEST PER COLONY (1000s)		
			35	*40*	*45*
LOW	SSB1 (x 1000 t)	110571			
	SSB2 (x 1000 t)	159589	Expected chicks per colony		
	$\theta(1)$ %	0.384 (0.342-0.429)	26,868	30,706	34,544
	$\theta(2)$ %	0.420 (0.365-0.478)	29,379	33,576	37,773
	Delta (N)		2 511	2 870	3 229
	Delta (%)		9.3%		
MEDIUM	SSB1 (x 1000 t)	220496			
	SSB2 (x 1000 t)	318245	Expected chicks per colony		
	$\theta(1)$ %	0.452 (0.386-0.522)	31,643	36,163	40,683
	$\theta(2)$ %	0.489 (0.411-0.572)	34,246	39,139	44,031
	Delta (N)		2 600	2 975	3 347
	Delta (%)		8.3%		
HIGH	SSB1 (x 1000 t)	404048			
	SSB2 (x 1000 t)	583168	Expected chicks per colony		
	$\theta(1)$ %	0.514 (0.427-0.603)	35,946	41,081	46,217
	$\theta(2)$ %	0.551	38,548	44,055	49,561

RECRUITMENT		VALUE	NUMBER OF NEST PER COLONY (1000s)		
			35	*40*	*45*
		(0.452-0.649)			
	Delta (N)		2 601	2 973	3 345
	Delta (%)		7.3%		

3.4.4 Projected population level effects

3.4.4.1 Results from the linked fisheries projections and kittiwake breeding success were passed to PVAs for the Flamborough Head SPA. The PVAs were run with Natural England's 'nepva' R package (v4.17), in R V4+ (R Core Team, 2020). For each PVA, matched-pair simulations were run contrasting the status quo fishing (Total_F) as baseline, with the 10% reduced fishing mortality (partial_F) as contrast. This is further conducted under the three broad levels of recruitment outline previously.

3.4.4.2 The PVAs simulate with the parameters given in and over their associated uncertainties. Simulation envelopes a presented in **Figure F 11** and **Figure F 12**– the former giving the projected population sizes going forwards, with the latter giving the differences between the baseline status quo fishing mortality and speculative reduced fishing mortality.

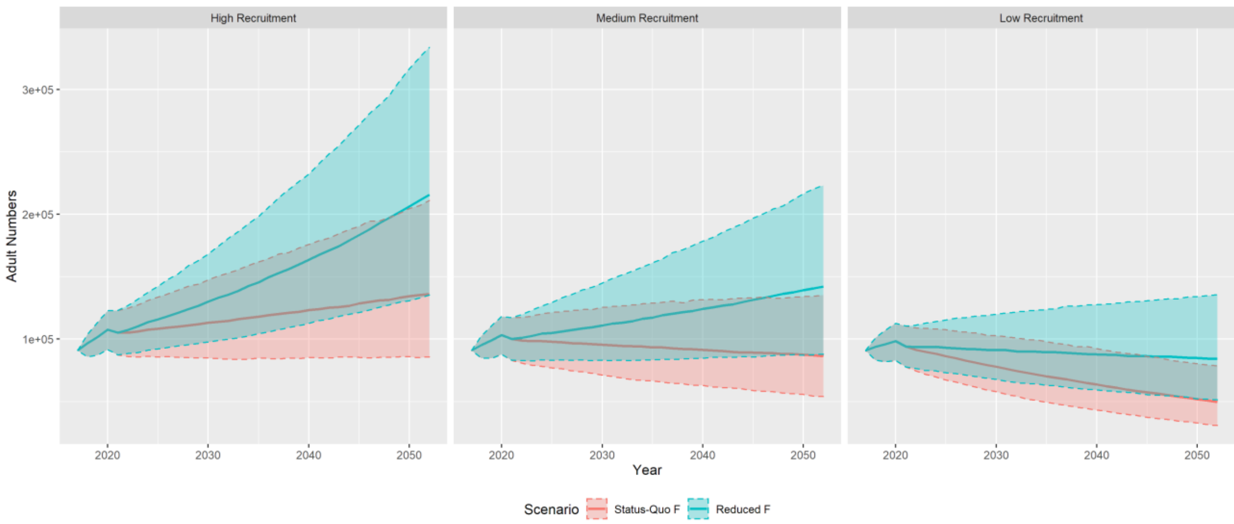


Figure F 11: 20-year PVA projections for adults at the Flamborough Head SPA, under three levels of recruitment (high, medium, low from left to right), and two fishing mortality rates (blue – reduced F, red – status quo F).

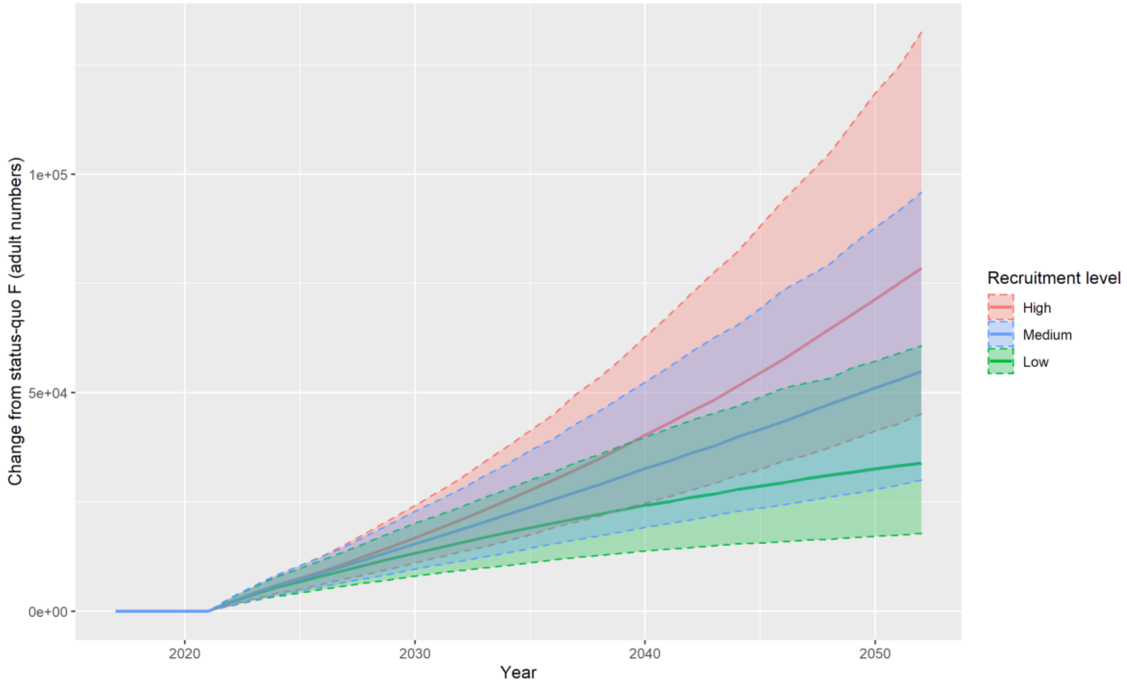


Figure F 12: 20-year PVA projections for differences in adults at the Flamborough Head SPA under the two fishing mortalities (reduced F – status quo F). Three levels of recruitment are presented (high, medium, low). Note, the population may be decreasing in actual size, despite a positive difference between fishing scenarios.

Table F 5: Median projected adult kittiwake numbers for the Flamborough Head SPA under, under three levels of recruitment, and two fishing mortality rates (baseline/status quo F and reduced by 10%).

RECRUITMENT	YEAR	BASELINE F	REDUCED F	%-AGE CHANGE
High	2027	111042.	121915.	9.79
	2037	120577.	153619.	27.4
Low	2027	83325.	92887.	11.5
	2037	67985.	89574.	31.8
Medium	2027	97482.	107916.	10.7
	2037	92936.	120627.	29.8

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Appendix F 1: PVA Parameterisation and Ring recapture data

1 PVA parameterisation

Table F 6: PVA parameters adopted throughout this report.

SPA	Age first breeding1	Eggs/pair2	Survivals						Productivity
				S0→1	S1→2	S2→3	S3→4	S4	PA
Mean Maximum Foraging Range									
Flamborough Head and Bempton Cliffs	4	2	Mean	0.790	0.854	0.854	0.854	0.854	0.855
			SD		0.051	0.051	0.051	0.051	0.331
Mean Maximum Foraging Range + 1 SD									
St Abb's Head to Fast Castle	4	2	Mean	0.790	0.854	0.854	0.854	0.854	0.623
			SD		0.051	0.051	0.051	0.051	0.316
Farne Islands[3, 5]	4	2	Mean	0.790	0.854	0.854	0.854	0.854	0.824
			SD		0.051	0.051	0.051	0.051	0.316
Coquet Island	4	2	Mean	0.790	0.854	0.854	0.854	0.854	0.824
			SD		0.051	0.051	0.051	0.051	0.316
Forth Islands	4	2	Mean	0.790	0.854	0.854	0.854	0.854	0.674
			SD		0.051	0.051	0.051	0.051	0.357
Mean Maximum Foraging Range + 2 SD									
Buchan Ness to Collieston Coast	4	2	Mean	0.790	0.854	0.854	0.854	0.854	0.632
			SD		0.051	0.051	0.051	0.051	0.333
Fowlsheugh	4	2	Mean	0.790	0.854	0.854	0.854	0.854	0.738
			SD		0.051	0.051	0.051	0.051	0.301
Troup, Penn and Lion's Heads	4	2	Mean	0.790	0.854	0.854	0.854	0.854	1.109
			SD		0.051	0.051	0.051	0.051	0.252

Table F 7: Sources and observations related to the choice of demographic parameters described in Table F 6.

SPA	Demographic parameter	Source	Comments
Flamborough Head and Bempton Cliffs	P_A	SMP (2021)	Mean and SD calculated from annual breeding success data collected in SPA (2010-2019)
	$S_{0\to1}, \ldots, S_A$	Horswill and Robinson (2015)	No SPA-specific survival data available. UK levels estimates deemed appropriate (Table 18 *in* Horswill and Robinson, 2015).
Coquet Island	P_A	SMP (2021)	Mean and SD calculated from annual breeding success data collected in SPA (1993-2019).
	$S_{0\to1}, \ldots, S_A$	Horswill and Robinson (2015)	No SPA-specific survival data currently available. UK levels estimates deemed appropriate
St Abb's Head to Fast Castle	P_A	SMP (2021)	Mean and SD calculated from annual breeding success data collected in SPA (1987-2019).
	$S_{0\to1}, \ldots, S_A$	Horswill and Robinson (2015)	No SPA-specific survival data currently available. UK levels estimates deemed appropriate
Farne Islands	P_A	SMP (2021)	Mean and SD calculated from annual breeding success data collected in SPA (1987-2015).
	$S_{0\to1}, \ldots, S_A$	Horswill and Robinson (2015)	No SPA-specific survival data currently available. UK levels estimates deemed appropriate
Forth Islands	P_A	CEH (2018)	Mean and SD based on annual breeding success estimates collected in Isle of May (2010 – 2016).
	$S_{0\to1}, \ldots, S_A$	Frederiksen et al. (2014)	Mean and SD based on adult survival estimates for the Isle of May
Buchan Ness to Collieston Coast	P_A	SMP (2021)	Mean and SD calculated from annual breeding success data collected in SPA (1989-2019).
	$S_{0\to1}, \ldots, S_A$	Horswill and Robinson (2015)	No SPA-specific survival data currently available. UK levels estimates deemed appropriate
Fowlsheugh	P_A	SMP (2021)	Mean and SD calculated from annual breeding success data collected in SPA (1986-2019).
	$S_{0\to1}, \ldots, S_A$	Horswill and Robinson (2015)	No SPA-specific survival data currently available. UK levels estimates deemed appropriate
Troup, Penn and Lion's Heads	P_A	SMP (2021)	Mean and SD calculated from annual breeding success data collected in SPA (2010-2019).

SPA	Demographic parameter	Source	Comments
	$S_{0\to1}, \ldots, S_A$	Horswill and Robinson (2015)	No SPA-specific survival data currently available. UK levels estimates deemed appropriate

Table F 8: Time-series of black-legged kittiwake counts (AONs) recorded in SPAs of interest. Data gathered and combined from SMP (2021).

Year	Flamborough Head and Bempton Cliffs	Northumberland Marine	St Abb's Head to Fast Castle SPA	Farne Islands SPA	Forth Islands SPA	Buchan Ness to Collieston Coast SPA	Fowlsheugh SPA	Troup, Penn and Lion's Heads SPA
1986				4388				16594
1987	85395			5915				
1988				5860				
1989				6148				
1990		7413	17642	6393	9764			
1991		6888	16183	5743	7360		23522	
1992		7470	16524	6178	7628		58700	
1993		5910	15268	5889	8573			
1994		5642	13007	5620	4801			
1995		6360	13670	6313	9199	24957		31664
1996		6281	13437	6236	9377			
1997		6180	13393	6119	10693			
1998		5053	8044	5009[†, 1]	4549			
1999		5543	9576	5492	6354		28447[†, 2]	
2000	42582	8679	16222	5125	6632		4739	
2001		5847	8028	5781	5109	14091		18665[†, 3]
2002		5136	8890	5055	5277			
2003		5276	6642	5192	5092			
2004		5236	6239	5151	5380	13330		15570
2005		5503	7239	5376	5196			
2006		4875	6288	4713	4593		11140	
2007		4826	6463	4669	4649	12542		14896[†, 3]
2008	37617	4436	5298	4275	4522			
2009		3867	4616	3699	3654		9454	
2010		4951	4744	4768	4827			
2011		4169	4688	3976	3884			
2012		4456	4314	4241	3766		9337	
2013		3628	4716	3443	2450			
2014		4463	3625	4175	3339			
2015		4282	4209	3956	4785		9655	7180
2016	45563	3844	3334	3527	4075			
2017	45504	5201	4803	4753[†, 1]	4663			10616
2018		3519	3244	3158	3514		14039	
2019		6115	4651	4402	1145	11295		
2020			4902		346			

† Divergences with data published in SMP Report 1986–2018 (Table 1, https://jncc.gov.uk/our-work/black-legged-kittiwake-rissa-tridactyla/)
[1] Smaller values than official/SMP figures (5,096 in 1998; 5,327 in 2017).
[2] Markedly different to official/SMP figures (18,800 in 1999). Potentially an error in report as, from the database, it looks like counts were not summed over the sites in the SPA, as it is common practice in later years.
[3] Values larger than official/SMP figures (18,482 in 2001; 10,503 in 2007).

1.1 Ring recapture data

1.1.1.1 The following ring recovery data is from O'Hanlon et al. (2021).

1.1.2 Chick recoveries

Table F 9: Dispersal distances of individuals from their natal colony (where they were ringed) to where they were recovered during or after their fourth summer, during the breeding season (April – July).

Distance recovered from ringing location (km)	Number of recapture events (%) by finding condition*					
	Dead N = 327		**Resighted N = 305**		**Re-trapped N = 637**	
	(327 individuals)		(270 individuals)		(634 individuals)	
≤ 3	107	(0.33)	201	(0.66)	467	(0.73)
3 > & ≤ 10	28	(0.09)	0	(0.00)	10	(0.02)
10 > & ≤ 50	63	(0.19)	10	(0.03)	58	(0.09)
50 > & ≤ 100	34	(0.10)	7	(0.02)	27	(0.04)
100 > & ≤ 200	23	(0.07)	16	(0.05)	4	(0.01)
200 > & ≤ 500	31	(0.09)	37	(0.12)	24	(0.04)
500 > & ≤ 1000	31	(0.09)	30	(0.10)	45	(0.07)
> 1000	10	(0.03)	4	(0.01)	2	(0.00)
Mean distance (km) ± SD	193 ± 1014		128 ± 243		78 ± 215	
Maximum distance (km)	3673		1293		1221	

1.1.3 Adult recoveries

Table F 10: Dispersal distances of adults from the colony where they were first ringed to where they were recaptured, during the breeding season (April – July).

Distance recaptured from ringing location (km)	Number of recovery events (%) by finding condition*					
	Dead N = 198 (197 individuals)		**Resighted N = 746 (716 individuals)**		**Re-trapped N = 1912 (1907 individuals)**	
≤ 3	71	(0.36)	725	(0.97)	1885	(0.99)
3 > & ≤ 10	17	(0.09)	0	(0.00)	15	(0.01)
10 > & ≤ 50	48	(0.24)	9	(0.01)	7	(0.00)
50 > & ≤ 100	22	(0.11)	2	(0.00)	2	(0.00)

100 > & ≤ 200	14	(0.07)	2	(0.00)	3	(0.00)
200 > & ≤ 500	10	(0.05)	5	(0.01)	0	(0.00)
500 > & ≤ 1000	9	(0.05)	2	(0.00)	0	(0.00)
> 1000	7	(0.04)	1	(0.00)	0	(0.00)
Mean distance (km) ± SD	154 ± 505		10 ± 113		0.5 ± 7	
Maximum distance (km)	4136		2658		176	