Sheringham Shoal and Dudgeon Offshore Wind Farm Extension Projects

Annex 1A - Initial Review of Compensatory Measures for Sandwich Tern and Kittiwake

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Glossary of Acronyms

BDMPS	Biologically Defined Minimum Population Size
CPGR	Counterfactual of Population Growth Rate
CPS	Counterfactual of Population Size
CRM	Collision Risk Model
DCO	Development Consent Order
DEP	Dudgeon Extension Project
DO	Dissolved Oxygen
ETG	Expert Topic Group
HRA	Habitats Regulations Assessment
MMO	Marine Management Organisation
NGO	Non-Governmental Organisations
NNC	North Norfolk Coast
OMP	Ornithological Monitoring Programme
PEIR	Preliminary Environmental Information Report
SEP	Sheringham Shoal Extension Project
SPA	Special Protection Areas
UK	United Kingdom

Glossary of Terms

The Applicant	Equinor New Energy Limited
Dudgeon Offshore Wind Farm Extension site	The Dudgeon Offshore Wind Farm Extension offshore wind farm boundary.
The Dudgeon Offshore Wind Farm Extension Project (DEP)	The Dudgeon Offshore Wind Farm Extension site as well as all onshore and offshore infrastructure.
Sheringham Shoal Offshore Wind Farm Extension site	Sheringham Shoal Offshore Wind Farm Extension offshore wind farm boundary.
The Sheringham Shoal Offshore Wind Farm Extension Project (SEP)	The Sheringham Offshore Wind Farm Extension site as well as all onshore and offshore infrastructure.

1 INTRODUCTION

1.1 Background

1. The Dudgeon Extension Project (hereafter DEP) and Sheringham Shoal Extension Project (hereafter SEP) are proposed extensions to the existing Dudgeon and Sheringham Shoal offshore wind farms. When operational, DEP and SEP combined will have the potential to generate renewable power for 820,000 United Kingdom (UK) homes from up to 32 wind turbines at DEP and up to 24 wind turbines at SEP. DEP and SEP are currently at the pre-application stage, with the programme at the time of writing being for consultation on a Preliminary Environmental Information Report (PEIR) starting in April 2021, followed by a Development Consent Order (DCO) application towards the end of 2021.

2. Equinor New Energy Limited ('the Applicant') has taken note of the outcome of the recent Hornsea Project Three decision, specifically the Secretary of State's decision letter which states that "*It is therefore important that potential adverse impacts on the integrity of designated sites are identified during the pre-application period and full consideration is given to the need for derogation of the Habitats Regulations during the examination. He expects Applicants and statutory nature conservation bodies ("SNCBs") to engage constructively during the pre-application period and provide all necessary evidence on these matters, including possible compensatory measures, for consideration during the examination.*"

3. It is possible that the Project activities could be capable of significantly affecting the protected features of designated sites. As part of the ongoing Habitats Regulations Assessment (HRA) these sites have been screened in for further consideration in an appropriate assessment (Equinor, 2020). The appropriate assessment has not yet been completed and while the Applicant does not wish to pre-empt the conclusions of that assessment, it is anticipated that if there is potential for an adverse effect on integrity of the sites in question, the Planning Inspectorate (PINS) will expect Stages 3 and 4 of the HRA process (**Plate 1-1**) to be considered pre-application.

4. With the above in mind the Applicant has given early consideration to which designated sites this might apply to, so that constructive engagement on the issues can be undertaken during the pre-application period. Initial discussions with Natural England and other relevant stakeholders have been held both in terms of the process to be followed at the pre-application stage, as well as the identity of the designated sites for consideration. This draft document describes outline in-principle compensatory measures where they apply to Special Protection Areas (SPAs) to ensure that any proposals for compensatory measures for DEP & SEP take account of stakeholder advice.

5. The provision of evidence regarding in-principle compensatory measures at this stage is entirely without prejudice to the Applicant's current position that there will be no adverse effect on integrity of any designated site.

Plate 1-1: HRA Process

Stage 1: Screening

- The process of identifying potentially relevant European sites, and whether the proposed plan or project is likely to have a significant effect on the qualifying interest features of the European site, either alone or in-combination with other plans and projects.
- In HRA, "significant" is used differently to EIA; a 'pathway for effect' through potential connectivity with a Natura 2000 site results in LSE being determined and the site being screened in to Stage 2.

Stage 2: Appropriate Assessment

- Assessment of the potential effects of the plan or project on the integrity of the European site(s) screened in, in view of their qualifying interest features and associated conservation objectives.
- Where it is concluded (taking account of mitigation) that there would be an adverse effect on site integrity (or where such an effect cannot be discounted), the HRA must progress to Stages 3 and 4.

Derogation Tests (Habitats Directive Article 6(4)

Stage 3: Assessment of Alternative Solutions

- The assessment should identify and examine alternative ways of achieving the objectives of the project to establish whether there are solutions that would avoid, or have a lesser effect, on the European site(s).
- Alternative solutions can include a project of a different scale, in a different location, and the 'do nothing' scenario.
- Where it can be demonstrated that there are no alternative solutions that would have a lesser effect on the Natura 2000 site(s), the process can move to Stage 4.

Stage 4 [part 1]: Imperative Reasons of Over Riding Public Interest (IROPI)

- Where Stage 3 can be satisfied, the project may be carried out if the competent authority is satisfied that the scheme must be carried out for IROPI, subject to the identification of appropriate compensatory measures.

Stage 4 [part 2]: Compensation

- Where it can be demonstrated that the scheme must be carried out for IROPI, compensatory measures that would maintain the overall coherence of the Natura 2000 network must be identified.
- The project proponent must demonstrate that such measures can be secured and, ideally, delivered at the point the adverse effect would occur.

1.2 Legislative Requirement and Guidance

6. The Conservation of Habitats and Species Regulations 2017 and The Conservation of Offshore Marine Habitats and Species Regulations 2017 (as amended) (the "Habitats Regulations") require that the appropriate authority must ensure that any necessary compensatory measures are secured (without prejudice to other requirements first being met[1]), where an adverse effect on the integrity of a European site (or sites) cannot be avoided, after the application of available, viable mitigation. Compensatory measures must be independent of the project (including any mitigation) and are intended to offset the residual negative effects of the plan or project so that the overall ecological coherence of the network is maintained.

7. DEFRA (2012) and EC (2012 and 2018) explain that for SPAs, the overall coherence of the Natura 2000 Network can be maintained by:

   - Compensation that fulfils the same purposes that motivated the site's designation;
   - Compensation that fulfils the same function along the same migration path; and
   - The compensation site(s) are accessible with certainty by the birds usually occurring on the site affected by the project.

8. The guidance provides an element of flexibility, recognising that compensation of a 'like for like' habitat and/or in the same designated site may not be practicable. It is also clear that compensation should not be used to address issues that are causing designated habitats or species to be in an unfavourable condition, which is the responsibility of the UK Government.

9. Ideally, compensation should be functioning before the effect takes place, although it is recognised that this may not always be possible, as stated in the EC (2012) guidance: "*in principle, the result of implementing compensation has normally to be operational at the time when the damage is effective on the site concerned. Under certain circumstances where this cannot be fully fulfilled, overcompensation would be required for the interim losses*."

[1] Including demonstrating that the need for the Project cannot be delivered through alternative solutions and that Imperative Reasons of Overriding Public Interest (IROPI) exist.

1.3 Purpose of this Document

10. The Applicant expects that, in the event that the Secretary of State is unable to reach a conclusion of no adverse effect on the integrity of any European site, a requirement will be included in the DCO for the submission and approval of a Compensation Plan for relevant European sites prior to the commencement of works. The Compensation Plan will confirm the compensatory measures that are required in relation to the final design of the Project. For the purpose of informing the DCO application and subsequent examination and decision making process, the Outline In-Principle Compensation Plan has been developed to demonstrate the feasibility of potential compensatory measures and to set out the information that will be required in the Final Compensation Plan that will be submitted prior to commencement. In doing so it demonstrates how the proposed works will be controlled by the DCO and gives greater confidence in the assumptions underpinning the approach to compensation.

11. This draft version of the Outline In-Principle Compensation Plan has been developed to inform early pre-application consultation with the members of the Ornithology Expert Topic Group (ETG), as a part of the Evidence Plan Process, to ensure that compensatory measures proposals for DEP & SEP take account of stakeholder advice. It is being provided ahead of the PEIR to maximise the timeframe available for discussions in the pre-application period.

2 Development of Potential Compensatory Measures – Methodology

2.1 General Approach

12. This initial review of potential compensatory measures aims at identifying the opportunities and constraints associated with all relevant potential measures in order to inform stakeholder consultation and identify the necessary next steps in determining a feasible approach.

13. The approach defines feasibility by the following aspects:

- Measure has a delivery mechanism that can be legally secured;
- Measure has a reasonable chance of success, is cost-effective and can be delivered in practical terms, including on a spatial scale sufficient to provide the appropriate level of compensation; and
- Measure can be delivered prior to the impact on the designated site/s taking place.

14. At this stage, both developer-led local measures and strategic measures are considered. Those that would appear to be more appropriate to be taken forward as part of a strategic approach by Government and industry, for example long term ecosystem-wide measures covering the potential impacts of multiple wind farms, will require a collaborative process between SNCBs, developers and non-governmental organisations (NGOs) working with UK Government.

2.2 Summary of Consultation

15. This section of the Final In-Principle Compensatory Measures Plan will summarise the details of the consultation undertaken in the development of that plan.

16. At this stage, and as discussed in **Section 1.1**, the Applicant has given early consideration to which designated sites compensatory measures might be required, so that constructive engagement on the issues can be undertaken during the pre-application period. **Table 2-1** provides a summary of the initial discussions undertaken by the Applicant to help inform the approach being taken at this early stage of the process.

Table 2-1: Summary of Consultation Undertaken in the Preparation of the Draft Outline Plan

Consultee	Date/Document	Details
Ornithology ETG members (including the Marine Management Organisation (MMO), Natural England and the Royal Society for the Protection of Birds (RSPB))	9th December 2020	The most recent (third) ornithology ETG considered some of the draft assessment outcomes and the plans for pre-application consultation on proposed compensatory measures were discussed.
Natural England	Various	Monthly project update meetings have been held since 2020, providing an opportunity to discuss the approach to the provision of information on in-principle compensatory measures.
PINS	16th November 2020	The Applicant provided a summary of the intended approach to derogation including the plans for pre-application consultation on proposed compensatory measures.
PINS	12th February 2021	The Applicant provided an update on the approach to derogation and a discussion was held around acceptance criteria and the sufficiency of information for examination. It was agreed that it would be helpful for the Project to provide draft documentation on derogation matters (specifically any proposed compensatory measures) for comment by PINS pre-application. The Applicant agreed to provide a programme and details of documents for pre-application consultation with PINS.

3 North Norfolk Coast SPA and Ramsar site

3.1 Site Description

3.1.1 Overview

17. The North Norfolk Coast SPA (NNC SPA) and Ramsar site is located east of The Wash on the northern coastline of Norfolk, and covers an area of nearly 8,000 hectares extending approximately 40km from Holme to Weybourne. The SPA was originally designated in January 1989, but the European Site Conservation Objectives were updated in February 2019. A variety of coastal habitats occur within the SPA, including intertidal mudflats and sandflats, coastal waters, saltmarshes, shingle, sand dunes, freshwater grazing marshes and reedbeds. The North Norfolk Coast is also designated as a Ramsar site.

18. The site is important within Europe as one of the largest areas of undeveloped coastal habitat of its type, and at designation was the fourth most important wetland site for waterfowl in Britain.

19. The coastal waters along the North Norfolk Coast are shallow and follow the complex series of harbours and inlets along the coast. These support large populations of small fish including sandeel and sprat which provide vital food for breeding tern populations that occur within the SPA. The SPA citation states that the site qualifies under Article 4.1 of the Birds Directive by supporting up to 4,500 pairs of Sandwich terns (4,275 pairs according to the Ramsar site citation), up to 1,000 pairs of common terns (408 pairs according to the Ramsar site citation), and up to 400 pairs of little terns (291 pairs according to the Ramsar site citation).

20. The site also qualifies under Article 4.1 of the Birds Directive by supporting nationally important numbers of bittern, marsh harrier, Montagu's harrier, and avocet. As well as these species, smaller proportions of the national breeding populations of other species listed on Annex 1 of the Birds Directive are supported by the SPA; namely Arctic tern, kingfisher and short-eared owl.

21. The site qualifies under Article 4.2 of the Birds Directive as an internationally important wetland, regularly supporting, in winter, over 10,000 wildfowl (average over 20,000) and internationally important numbers of the following waterfowl species: 9,000 dark-bellied brent geese (8,960 according to the Ramsar site citation), 6,000 pink-footed-geese (16,787 according to the Ramsar site citation), 6,000 knot (30,781 according to the Ramsar site citation) and 5,600 wigeon (17,940 according to the Ramsar site citation. These species are joined on the Ramsar site citation by 1,148 pintails.

22. Whilst not qualifying features of the SPA, nationally important wintering numbers of the following species are also supported: 270 European white-fronted geese, 450 pintails, 2600 shelducks, 500 grey plovers, 400 ringed plovers, 5,000 oystercatchers and 800 redshanks. In addition, many of the huge wader flocks which feed in The Wash regularly use the western parts of this site as a safe high-water roost. The site supports also nationally important breeding populations of gadwall, shoveler, garganey, black-tailed godwit, bearded tit and parrot crossbill.

3.1.2 Conservation Objectives

23. The site's conservation objectives are to ensure that, subject to natural change, the integrity of the site is maintained or restored as appropriate, and that the site contributes to achieving the aims of the Wild Birds Directive, by maintaining or restoring:

- The extent and distribution of the habitats of the qualifying features
- The structure and function of the habitats of the qualifying features
- The supporting processes on which the habitats of the qualifying features rely
- The populations of each of the qualifying features
- The distribution of qualifying features within the site

24. More detailed conservation objectives have since been added online, last updated 13 September 2019 (Natural England 2020). For Sandwich tern at NNC SPA these are:

- Restore the size of the breeding population to a level which is above 4,500 pairs, whilst avoiding deterioration from its current level as indicated by the latest mean peak count or equivalent.
- Maintain safe passage of birds moving between nesting and feeding areas
- Reduce the frequency, duration and / or intensity of disturbance affecting roosting, nesting, foraging, feeding, moulting and/or loafing birds so that they are not significantly disturbed.
- Restrict predation and disturbance caused by native and non-native predators
- Maintain concentrations and deposition of air pollutants at below the site-relevant Critical Load or Level values given for this feature of the site on the Air Pollution Information System (www.apis.ac.uk).
- Maintain the structure, function and supporting processes associated with the feature and its supporting habitat through management or other measures (whether within and/or outside the site boundary as appropriate) and ensure these measures are not being undermined or compromised.
- Maintain the extent, distribution and availability of suitable habitat (either within or outside the site boundary) which supports the feature for all necessary stages of its breeding cycle (courtship, nesting, feeding) at levels described in site specific supporting notes.
- Maintain the distribution, abundance and availability of key food and prey items (eg. sandeel, sprat) at preferred sizes. The availability of an abundant food supply is critically important for successful breeding, adult fitness and survival and the overall sustainability of the population.
- Maintain the availability of shallow sloping nesting sites, grading to <30 cm above water level, restricting the probability that they will flood.

- Maintain vegetation cover which should be <10% throughout areas used for nesting, providing sufficient bare ground for the colony as a whole.
- Restrict aqueous contaminants to levels equating to High Status according to Annex VIII and Good Status according to Annex X of the Water Framework Directive, avoiding deterioration from existing levels.
- Maintain the dissolved oxygen (DO) concentration at levels equating to High Ecological Status (specifically ≥ 5.7 mg per litre (at 35 salinity) for 95 % of the year), avoiding deterioration from existing levels
- Maintain water quality at mean winter dissolved inorganic nitrogen levels where biological indicators of eutrophication (opportunistic macroalgal and phytoplankton blooms) do not affect the integrity of the site and features, avoiding deterioration from existing levels.
- Maintain natural levels of turbidity (e.g. concentrations of suspended sediment, plankton and other material) across the habitat.

25. In addition, a Site Improvement Plan was published in December 2014, outlining the prioritised issues for the site and features, and the proposed measures to address those issues (**Section 3.1.4**).

3.1.3 Interest Feature – Breeding Sandwich Tern

26. The biogeographic population (*Thalasseus sandvicensis*) was estimated at 74,000 pairs, of which 11,000 pairs breed in Great Britain and 3,700 pairs in all-Ireland (Mitchell et al. 2004). Sandwich tern breeding numbers in the UK increased from the 1920s to the mid-1980s, after major reductions caused by human exploitation and hunting (JNCC 2020). National surveys showed an increase in the UK population of 33% from 1969 to 1986, but a decrease of 15% from 1986 to 2000 (JNCC 2020). JNCC SMP data show no clear long-term trend for UK breeding numbers between 1986 and 2018, with the index in 2018 almost the same as in 1986 (JNCC 2020).

27. Stroud et al. (2016) identified that the SPA suite with breeding Sandwich tern as a designated feature has 13 qualifying sites in Great Britain, three in Scotland (Forth Islands SPA; Loch of Strathbeg SPA; Ythan Estuary, Sands of Forvie and Meikle Loch SPA), nine in England (Alde-Ore Estuary SPA; Chichester and Langstone Harbours SPA; Coquet Island SPA; Duddon Estuary SPA; Farne Islands SPA; Foulness SPA; Morecambe Bay SPA; NNC SPA; Solent and Southampton Water SPA) and one in Wales (Ynys Feurig, Cemlyn Bay and The Skerries SPA, now known as Anglesey Terns SPA). The SPAs in Great Britain were estimated to hold 72% of the Great Britain breeding population of Sandwich terns present in 2000 (Stroud et al. 2016). Three sites in Northern Island also qualify (Carlingford Lough; Larne Lough; and Strangford Lough). NNC SPA held 3,700 pairs of Sandwich terns at designation, the largest breeding population of the species in the UK SPA suite. Numbers have decreased at many of the SPA sites, but have increased at some, including NNC SPA, such that the overall change since designation is small. Similarly, the JNCC seabird monitoring index for Sandwich tern suggests that current numbers in England (in 2020) are very similar to numbers present in 1986; the index in 2020 being essentially the same as in 1986 despite periods in the mid-1990s and early 2010s when the index fell below 100 (JNCC, 2020).

28. Within the boundary of the NNC SPA, Sandwich terns breed at two principal colonies; Blakeney Point and Scolt Head (JNCC, 2020; Perrow et al., 2017). Alternative breeding locations within the SPA, such as Holkham, have been unused since 2004 (JNCC, 2020).

29. Long-term and short-term trends in the NNC SPA Sandwich tern population are described in the data presented in **Plate 3-1** and **Plate 3-2** (showing number of pairs from Apparently Occupied Nests (AONs)), whilst **Table 3-1** presents population and productivity data from the last ten years. Though population size has at times fluctuated since 1989, the recent trend is an increasing one (**Plate 3-1**). The most recent, but as yet unpublished counts (R. Fijn, pers. comm.) estimated the population to be 13,170 breeding adults in 2020.

Plate 3-1: Number of Pairs (AONs) of Sandwich Tern Recorded at NNC SPA from 1969 to 2018, with Best Linear Trend Line Fitted. Data from JNCC SMP Database. There is No Significant Long-Term Trend over this Period

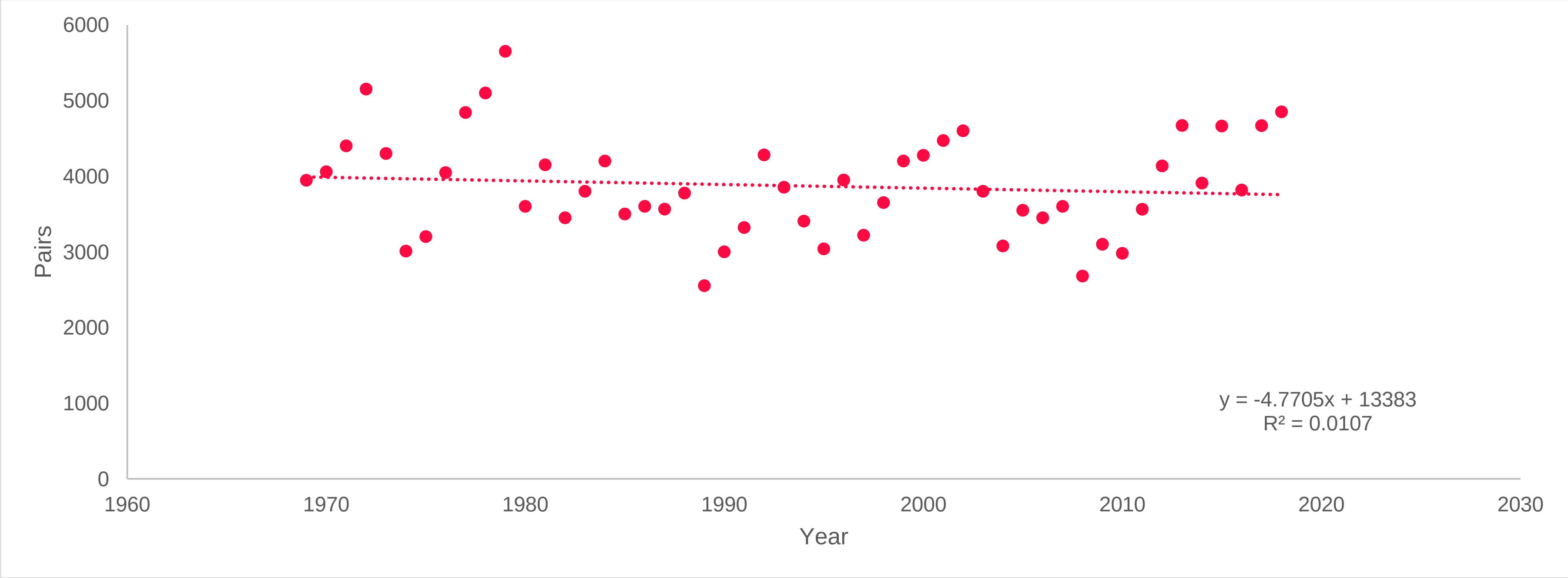


Plate 3-2: Number of Pairs (AONs) of Sandwich Tern Recorded at NNC SPA from 2008 to 2018, with Best Linear Trend Line Fitted. Data from JNCC SMP Database. The trend Since 2008 has been a Statistically Significant Increase in Breeding Numbers

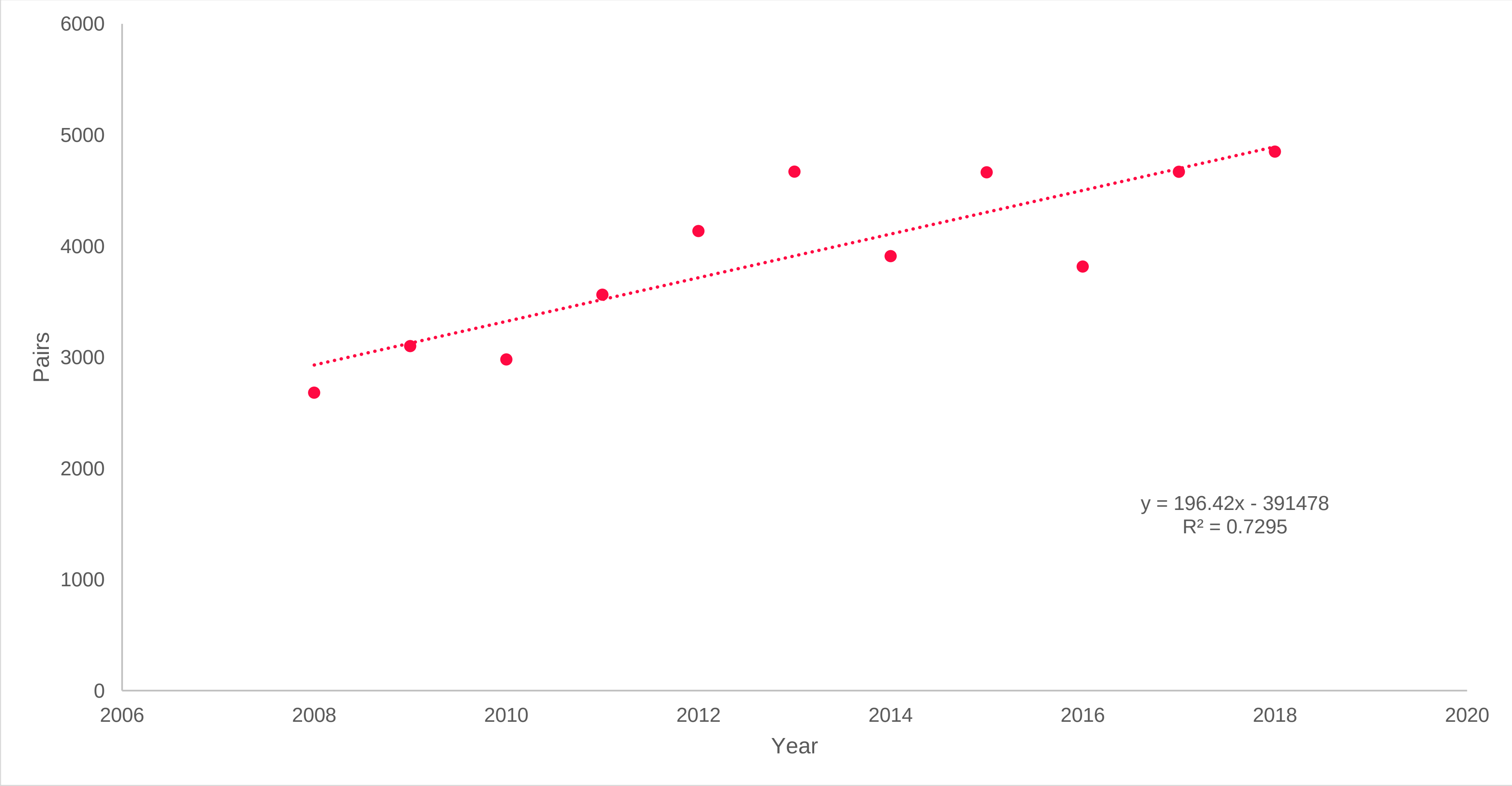


Table 3-1: Annual Sandwich Tern Population Estimation and Breeding Success at the NNC SPA by Breeding Colony since 2010 (JNCC, 2020, Apart from Scolt Head Data for 2019 and 2020 which are Unpublished Counts).

Year	Scolt Head		Blakeney Point		Total Adults
	AON	Success	AON	Success	
2010	480	0	2,500	0.36	5,960
2011	0	-	3,562	0.52	7,124
2012	400	0	3,735	0.59	8,270
2013	550	0	4,120	0.44	9,340
2014	1,050	0.60	2,859	0.19	7,818
2015	3,550	0.90	1,113	0.01	9,326
2016	3,365	0.80	451	0.39	7,632
2017	4,665	0.94	3	0	9,336
2018	4,685	0.85	165	0.12	9,700
2019	3,805	No data	788	0.51	9,186
2020	4,160	0.72	2,425	0.45	13,170

30. Since 2015, the majority of Sandwich terns breeding in the NNC SPA have been located at Scolt Head, and not Blakeney Point, which was the location with the most breeding activity from 1979 to 2015, but held very few birds before 1976 (JNCC, 2020). In 2019 and 2020, numbers of birds breeding at Blakeney Point have increased (JNCC, 2020). Data for Scolt Head in 2019 and 2020 are unpublished counts (T. Bolderstone, pers. comm.).

31. The selection of a preferred breeding location generally shifts every few years, and is thought to be due to a number of reasons. These include the presence of black-headed and large gulls at the start of the breeding season, the presence of non-avian predators (e.g. foxes), and the state of vegetation. Sandwich terns are highly vulnerable to mammal predators and declines at colonies are most often related to an increase in predator access, especially to foxes, but also rats, stoats and American mink. Predators can cause complete abandonment of a colony, or periodic breeding failure (Mitchell et al. 2004). Predation by gulls can also influence breeding success but tends to be less of a problem than predation by mammals. Sandwich tern nesting habitat is dynamic, with influences of coastal erosion and flooding potentially leading to habitat loss, and of plant succession potentially leading to habitat becoming overgrown and unsuitable for this species (Mitchell et al. 2004). Sandwich terns have been affected by chemical pollution, with very large decreases in breeding numbers in the Netherlands in the 1960s (Mitchell et al. 2004) but that pressure has been reduced. Breeding success can be strongly affected by forage fish abundance and breeding failures have been related to reductions in stocks of sandeel, sprat and juvenile herring. Overwinter survival may be influenced by fisheries off West Africa affecting abundance of forage fish in that region (Mitchell et al. 2004), and deliberate trapping of birds at the West African coast for sport and food has been identified as affecting survival, especially of immature birds.

3.1.4 Site Improvement Plan (SIP) in Relation to Sandwich Tern

32. Natural England identify the threats and pressures on Sandwich tern within NNC SPA and management actions in relation to these (published 19 December 2014).

3.1.5 Public Access / Disturbance

33. Investigate and identify measures to counteract effects of disturbance. Coordinate information exchange regarding sensitive areas. Timescale 2014-2020. Funding option “not yet determined”.

3.1.6 Fisheries: Recreational Marine and Estuarine

34. Implement the recreational sea angling strategy. Timescale 2015-2020. Funding option “not yet determined”.

3.1.7 Fisheries: Commercial Marine and Estuarine

35. Put in place necessary management measures. Introduction of management measures by Eastern Inshore Fisheries Conservation Authority. Timescale 2016 onwards. Funding option Defra, Natural England.

3.1.8 Predation

36. Ensure adequate protection of nesting birds from predators. Timescale 2014-2020. Funding option “not yet determined”.

3.1.9 Inappropriate Coastal Management

37. Although not specifically linked to Sandwich tern in the SIP, the plan states "Investigate the options for adaptive site management in light of ecological changes likely to occur due to increased frequency and duration of saline inundation". Timescale 2014-2016. Funding option "not yet determined".

3.2 Potential Impacts

38. The following sections provide a summary of the potential impacts on Sandwich tern at NNC SPA in order to help set the context for the discussion of potential compensatory measures that follows. All assessment outcomes at the time of writing are draft and may be subject to change.

3.2.1 Overview

39. The screening process undertaken in the development of the PEIR **ornithology** chapter has identified Sandwich tern as being of relatively high sensitivity to potential collision with operational offshore wind turbines at DEP and SEP, and also potentially susceptible to displacement during the operational phase. The species is considered to be insensitive to impacts relating to disturbance, displacement during construction and decommissioning, or any indirect impacts that may occur as a result of the construction, operation or decommissioning of DEP and SEP.

40. It is presumed that 100% of birds present at DEP and SEP during the breeding season are breeding adults from the NNC SPA and therefore 100% of all predicted impacts during the full breeding season (April to August) are attributable to this population. Outside the breeding season, impacts on Sandwich tern have been compared to the appropriate Biologically Defined Minimum Population Size (BDMPS) for the season in question. The relevant background population is considered to be the UK North Sea and Channel BDMPS, consisting of 38,051 individuals during autumn migration (July to September) and spring migration (March to May) (Furness, 2015). During both autumn and spring migration seasons, 31.3% of all impacts are attributable to birds from the NNC SPA and Ramsar site. This is based on the SPA population of breeding adults in each season as a proportion of the seasonal UK and North Sea BDMPS population, from population estimates in Furness (2015).

3.2.2 Quantification of Effect – Displacement

41. Seasonal and annual population estimates of Sandwich terns at DEP and SEP are provided in **Table 3-2**. This table also includes seasonal and annual population estimates for all OWFs included in the in combination assessment again for the development and a buffer of 0km, though due to data availability, only birds in flight are included in the totals for OWFs other than DEP and SEP (further details will be presented in the PEIR, **Appendix 13.1 Offshore Ornithology Technical Report**).

42. The number of birds expected to die as a result of displacement from each OWF is presented in

43. Table 3-3. Displacement rates of 30% to 50%, and maximum mortality rates of 1% to 5% of displaced birds, are considered as the potential range of displacement effects.

Table 3-2: Seasonal and Annual Population Estimates of Sandwich Terns at DEP, SEP and Other OWFs Included in the In-Combination Assessment, Apportioned to NNC SPA and Ramsar Site

Tier	OWF	No. Sandwich terns at risk of displacement							
		Spring		Breeding		Autumn		Annual	
		Total	NNC	Total	NNC	Total	NNC	Total	NNC
1	Dudgeon	0	0	47	47	0	0	47	47
1	Race Bank	2	1	43	43	3	1	48	44
1	Sheringham Shoal	0	0	15	15	2	1	18	17
2	Triton Knoll	0	0	18	18	0	0	18	18
5	DEP	0	0	179	179	45	14	224	193
5	SEP	0	0	77	77	0	0	77	77
Totals		**2**	**1**	**379**	**379**	**50**	**16**	**431**	**396**

Table 3-3: Number of Sandwich Terns Predicted to Die Annually as a Result of Displacement from DEP, SEP, and other OWFs in the Greater Wash, Apportioned to the NNC SPA and Ramsar Site, Based on Displacement Rates of 30% to 50%, and Mortality Rates of 1% to 5%

Tier	OWF	No. Sandwich terns at risk of mortality			
		Spring	Breeding	Autumn	Annual
1	Dudgeon	0	0 - 1	0	0 - 1
1	Race Bank	0	0 - 1	0	0 - 1
1	Sheringham Shoal	0	0	0	0

Tier	OWF	No. Sandwich terns at risk of mortality			
		Spring	Breeding	Autumn	Annual
2	Triton Knoll	0	0	0	0
5	DEP	0	1 - 4	0 - 1	1 - 5
5	SEP	0	0 - 2	0	0 - 2
Totals		**0**	**1 - 8**	**0 - 1**	**1 - 9**

44. The annual total of Sandwich terns from the NNC SPA and Ramsar site at risk of displacement from DEP and SEP combined is 270 birds (193 at DEP and 77 at SEP). At displacement rates of 30% to 50% and a mortality rate of 1% to 5% for displaced birds, one to five SPA breeding adults would be predicted to die each year due to displacement from DEP, and zero to two birds due to displacement from SEP. When combined, this would increase the baseline mortality of the SPA breeding population by 0.1% to 0.7%. It is considered that the lower end of this range represents an appropriate worst case scenario, as the presence of an operational OWF may only increase energy expenditure of breeding adults by 1% per day (Masden 2010), which is unlikely to result in a large amount of additional mortality.

45. As predicted increases in baseline mortality of breeding adult Sandwich tern of less than 1% are likely to be undetectable against natural variation, it is concluded that under all Project alone scenarios, predicted mortality due to operational phase displacement at DEP, SEP and DEP and SEP combined would not adversely affect the integrity of the NNC SPA and Ramsar site.

46. The annual total of Sandwich terns from the NNC SPA and Ramsar site at risk of displacement from OWFs in the wider Wash area is 396 birds. At displacement rates of 30% to 50% and a mortality rate of 1% to 5% for displaced birds, one to nine SPA breeding adults would be predicted to die each year due to displacement from these OWFs. This would increase the baseline mortality of the SPA breeding population by 0.1% to 0.9%. It is considered that the lower end of this range represents an appropriate worst case scenario, as the presence of an operational OWF may only increase energy expenditure of breeding adults by 1% per day (Masden 2010), which seems unlikely to result in large amounts of additional mortality.

47. As predicted increases in baseline mortality of breeding adult Sandwich tern of less than 1% are likely to be undetectable against natural variation, it is concluded that predicted mortality due to operational phase displacement at OWFs in the wider Wash area would not adversely affect the integrity of the NNC SPA and Ramsar site.

3.2.3 Quantification of Effect – Collisions

48. Potential collision risk for kittiwake and DEP and SEP was estimated using the Band (2012) collision risk model (CRM). Full details of the input parameters used will be provided in the PEIR **chapter** and accompanying technical appendix. There is currently a lack of certainty on what the most appropriate avoidance rate is for this species. Natural England are taking their default position of assuming 0.980, whilst the assessment has considered three avoidance rates; 0.980, 0.9883 (used by the DECC (2012) HRA on this species), and 0.993 (calculated from data collected during the SOW OMP (Harwood et al. 2018)).

3.2.4 Project Alone

49. Seasonal and annual collision risk predictions for Sandwich tern at DEP, SEP, and DEP and SEP combined, apportioned to the NNC SPA and Ramsar site (means and upper and lower 95% confidence intervals), are shown in **Table 3-4**, **Table 3-5** and **Table 3-6**. These tables present outputs based on avoidance rates of 0.980, 0.9883 and 0.993 respectively. The scenarios considered included both 14MW and 26MW wind turbines i.e. a higher number of smaller turbines and a smaller number of larger turbines.

50. For DEP, the scenarios at the worst case 14MW deployment where the predicted increase in the annual baseline mortality would be greater than 1% is the upper 95% confidence limit outputs at avoidance rates of 0.980 and 0.9883. At the 26MW deployment, no scenarios modelled for DEP predict greater than a 1% mortality increase.

51. For SEP, no scenarios at either the 14MW or 26MW deployments result in a predicted annual mortality increase of greater than 1%.

52. For DEP and SEP combined, the scenarios at the worst case 14MW deployment where the predicted increase in the annual baseline mortality would be greater than 1% are the upper 95% confidence limit outputs at all avoidance rates, and the mean output at an avoidance rate of 0.980. However, the probability of two 95% upper confidence intervals occurring simultaneously is extremely small (0.06%). At the 26MW deployment, the only scenario where the predicted increase in the annual baseline mortality would be greater than 1% is the upper 95% confidence limit outputs at an avoidance rate of 0.980.

53. As there are a large number of potential variables in the current calculation of Sandwich tern collision risk, a range of possible collision rates are considered; for DEP and SEP combined, this is estimated to be between 10 and 25 individuals per year.

54. Scenarios A and B of the PVA produced for this assessment (further details will be presented in the PEIR, **Appendix 13.1 Offshore Ornithology Technical Report**) considers an initial annual mortality of 10 and 35 birds respectively. In these scenarios, the Counterfactual of Population Growth Rate (CPGR) is 0.999 and 0.996; in other words, the growth rate of the population compared with the baseline scenario is reduced by 0.1% to 0.4% due to these impacts. In the context of a population that has experienced a mean annual growth of 8.5% between 2010 and 2020, it is not considered that a reduction in the growth rate of this magnitude represents a substantial effect on the population. Whilst the Counterfactual of Population Size (CPS) for these PVA scenarios suggest that relatively large impacts on the population may be possible after 35 years of OWF operation, the discussion in **Appendix 13.1 Offshore Ornithology Technical Report** indicates that for a number of reasons, this metric may be producing population level effect predictions that are excessively precautionary.

55. As predicted increases in baseline mortality of breeding adult Sandwich tern of less than 1% are likely to be undetectable against natural variation, and those that are just over are not expected to produce large changes in mortality at the colony level, it is concluded that under all mean CRM output Project alone scenarios, predicted mortality due to operational phase collision at DEP, SEP and DEP and SEP combined would not adversely affect the integrity of the NNC SPA and Ramsar site.

Table 3-4: Predicted Seasonal and Annual Collision Mortality for Sandwich Tern at DEP and SEP Apportioned to NNC SPA and Ramsar Site (Avoidance Rate of 0.980)

Collision Mortality[1]		**Autumn Migration**			**Spring Migration**			**Breeding**			**Annual**		
Scenario		**LCL**[2]	**Mean**	**UCL**[2]	**LCL**	**Mean**	**UCL**	**LCL**	**Mean**	**UCL**	**LCL**	**Mean**	**UCL**
DEP	14MW	0.00	0.39	1.02	0.00	0.00	0.00	0.65	8.27	22.85	0.65	8.66	23.87
		Predicted increase in annual adult mortality rate[3]									0.07%	0.88%	2.41%
	26MW	0.00	0.12	0.36	0.00	0.00	0.00	0.23	2.53	7.92	0.23	2.65	8.28
		Predicted increase in annual adult mortality rate									0.02%	0.27%	0.84%
SEP	14MW	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00	7.45	0.00	2.00	7.45
		Predicted increase in annual adult mortality rate									0.00%	0.20%	0.75%
	26MW	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.71	2.63	0.00	0.71	2.63
		Predicted increase in annual adult mortality rate									0.00%	0.07%	0.27%
DEP and SEP	14MW	0.00	0.39	1.02	0.00	0.00	0.00	0.65	10.27	30.30	0.65	10.66	31.32
		Predicted increase in annual adult mortality rate									0.07%	1.08%	3.17%

Collision Mortality[1]		Autumn Migration			Spring Migration			Breeding			Annual		
Scenario		LCL[2]	Mean	UCL[2]	LCL	Mean	UCL	LCL	Mean	UCL	LCL	Mean	UCL
	26MW	0.00	0.12	0.36	0.00	0.00	0.00	0.23	3.24	10.55	0.23	3.36	10.91
		Predicted increase in annual adult mortality rate									0.02%	0.34%	1.10%

1. Number of individuals at avoidance rate of 0.980

2. LCL=Lower 95% confidence limit, UCL=Upper 95% confidence limit

3. With reference to baseline annual adult mortality rate 0.102

Table 3-5: Predicted Seasonal and Annual Collision Mortality for Sandwich Tern at DEP and SEP Apportioned to NNC SPA and Ramsar Site (Avoidance Rate of 0.9883)

Collision Mortality[1]		Autumn Migration			Spring Migration			Breeding			Annual		
Scenario		LCL[2]	Mean	UCL[2]	LCL	Mean	UCL	LCL	Mean	UCL	LCL	Mean	UCL
DEP	14MW	0.00	0.23	0.60	0.00	0.00	0.00	0.38	4.84	13.36	0.38	5.07	13.96
		Predicted increase in annual adult mortality rate[3]									0.04%	0.51%	1.41%
	26MW	0.00	0.07	0.20	0.00	0.00	0.00	0.13	1.48	4.63	0.13	1.55	4.83

Collision Mortality[1]		Autumn Migration			Spring Migration			Breeding			Annual		
Scenario		LCL[2]	Mean	UCL[2]	LCL	Mean	UCL	LCL	Mean	UCL	LCL	Mean	UCL
		Predicted increase in annual adult mortality rate									0.01%	0.16%	0.49%
SEP	14MW	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.17	4.36	0	1.17	4.36
		Predicted increase in annual adult mortality rate									0.00%	0.12%	0.44%
	26MW	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.41	1.54	0	0.41	1.54
		Predicted increase in annual adult mortality rate									0.00%	0.04%	0.16%
DEP and SEP	14MW	0.00	0.23	0.60	0.00	0.00	0.00	0.38	6.01	17.72	0.38	6.24	18.32
		Predicted increase in annual adult mortality rate									0.04%	0.63%	1.85%
	26MW	0.00	0.07	0.20	0.00	0.00	0.00	0.13	1.89	6.17	0.13	1.96	6.37
		Predicted increase in annual adult mortality rate									0.01%	0.20%	0.64%

1. Number of individuals at avoidance rate of 0.9883
2. LCL=Lower 95% confidence limit, UCL=Upper 95% confidence limit
3. With reference to baseline annual adult mortality rate 0.102

Table 3-6: Predicted Seasonal and Annual Collision Mortality for Sandwich Tern at DEP and SEP Apportioned to NNC SPA and Ramsar Site (Avoidance Rate of 0.993)

Collision Mortality[1]		Autumn Migration			Spring Migration			Breeding			Annual		
Scenario		LCL[2]	Mean	UCL[2]	LCL	Mean	UCL	LCL	Mean	UCL	LCL	Mean	UCL
DEP	14MW	0.00	0.14	0.36	0.00	0.00	0.00	0.23	2.89	8.00	0.23	3.03	8.36
		Predicted increase in annual adult mortality rate[3]									0.02%	0.31%	0.84%
	26MW	0.00	0.04	0.13	0.00	0.00	0.00	0.08	0.88	2.77	0.08	0.92	2.9
		Predicted increase in annual adult mortality rate									0.01%	0.09%	0.29%
SEP	14MW	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.70	2.61	0	0.70	2.61
		Predicted increase in annual adult mortality rate									0.00%	0.07%	0.26%
	26MW	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.92	0	0.25	0.92
		Predicted increase in annual adult mortality rate									0.00%	0.03%	0.09%
DEP and SEP	14MW	0.00	0.04	0.13	0.00	0.00	0.00	0.23	3.59	10.61	0.23	3.63	10.74

Collision Mortality[1]		**Autumn Migration**			**Spring Migration**			**Breeding**			**Annual**		
Scenario		**LCL[2]**	**Mean**	**UCL[2]**	**LCL**	**Mean**	**UCL**	**LCL**	**Mean**	**UCL**	**LCL**	**Mean**	**UCL**
		Predicted increase in annual adult mortality rate									0.02%	0.37%	1.09%
	26MW	0.00	0.04	0.13	0.00	0.00	0.00	0.08	1.13	3.69	0.08	1.17	3.82
	26MW	Predicted increase in annual adult mortality rate									0.01%	0.12%	0.39%

1. Number of individuals at avoidance rate of 0.993

2. LCL=Lower 95% confidence limit, UCL=Upper 95% confidence limit

3. With reference to baseline annual adult mortality rate 0.102

3.2.4.1 In-Combination

56. The seasonal and annual in combination totals of predicted collision mortality for the NNC SPA and Ramsar site Sandwich tern population are shown using consented OWF parameters in **Table 3-7**, **Table 3-8** and **Table 3-9**, and as-built OWF parameters in **Table 3-10**, **Table 3-11** and **Table 3-12**.

Table 3-7: In-Combination Collision Risk for Sandwich Terns of the NNC SPA and Ramsar Site using Consented OWF Parameters, Avoidance Rate 0.980

OWF	Autumn	Spring	Breeding	Total
Dudgeon	0	0	16.6	16.6
Race Bank	0.2	0.1	41.1	41.5
Sheringham Shoal	0.1	0.0	9.5	9.6
Triton Knoll	0	0	9.1	9.1
DEP (14MW)	0.2	0	8.3	8.5
SEP (14MW)	0	0	2.0	2.0
Total	**0.5**	**0.1**	**86.6**	**87.3**

Table 3-8: In-Combination Collision Risk for Sandwich Terns of the NNC SPA and Ramsar Site using Consented OWF Parameters, Avoidance Rate 0.9883

OWF	Autumn	Spring	Breeding	Total
Dudgeon	0	0	9.7	9.7
Race Bank	0.1	0.1	24.1	24.3
Sheringham Shoal	0.1	0.0	5.6	5.6
Triton Knoll	0	0	5.3	5.3
DEP (14MW)	0.2	0	4.8	5.0
SEP (14MW)	0	0	1.5	1.5
Total	**0.4**	**0.1**	**51.0**	**51.4**

Table 3-9: In-Combination Collision Risk for Sandwich Terns of the NNC SPA and Ramsar Site using Consented OWF Parameters, Avoidance Rate 0.993

OWF	Autumn	Spring	Breeding	Total
Dudgeon	0	0	5.8	5.8
Race Bank	0.1	0.0	14.4	14.5
Sheringham Shoal	0.0	0.0	3.3	3.4
Triton Knoll	0	0	3.2	3.2
DEP (14MW)	0.1	0	2.9	3.0
SEP (14MW)	0	0	0.7	0.7
Total	**0.2**	**0.0**	**30.3**	**30.6**

Table 3-10: In-Combination Collision Risk for Sandwich Terns of the NNC SPA and Ramsar Site using As-Built OWF Parameters, Avoidance Rate 0.980

OWF	Autumn	Spring	Breeding	Total
Dudgeon	0	0	5.7	5.7
Race Bank	0.1	0.0	10.8	10.9
Sheringham Shoal	0.1	0	4.9	5.0
Triton Knoll	0	0	1.3	1.3
DEP (14MW)	0.2	0	8.3	8.5
SEP (14MW)	0	0	2.0	2.0
Total	**0.4**	**0.0**	**33.0**	**33.4**

Table 3-11: In-Combination Collision Risk for Sandwich Terns of the NNC SPA and Ramsar Site using As-Built OWF Parameters, Avoidance Rate 0.9883

OWF	Autumn	Spring	Breeding	Total
Dudgeon	0	0	3.3	3.3
Race Bank	0.0	0.0	6.3	6.4
Sheringham Shoal	0.0	0	2.9	2.9
Triton Knoll	0	0	0.8	0.8
DEP (14MW)	0.2	0	4.8	5.0
SEP (14MW)	0	0	1.5	1.5
Total	**0.2**	**0.0**	**19.6**	**19.9**

Table 3-12: In-Combination Collision Risk for Sandwich Terns of the NNC SPA and Ramsar Site using As-Built OWF Parameters, Avoidance Rate 0.993

OWF	Autumn	Spring	Breeding	Total
Dudgeon	0	0	2.0	2.0
Race Bank	0.0	0.0	3.8	3.8
Sheringham Shoal	0.0	0	1.7	1.7
Triton Knoll	0	0	0.4	0.4
DEP (14MW)	0.1	0	2.9	3.0
SEP (14MW)	0	0	0.7	0.7
Total	**0.1**	**0.0**	**11.5**	**11.6**

57. Using the consented OWF scenarios at the worst case, either 30.6, 51.4 or 87.3 NNC SPA and Ramsar site Sandwich terns per year are predicted to die due to collisions with operational OWFs in the wider Wash area, depending on the avoidance rate used (0.993, 0.9883 or 0.980 respectively). This would represent a 3.1%, 5.2% or 8.8% increase in the existing annual mortality rate. Depending on the avoidance rate used, 26.9, 44.9 or 76.8 collisions per year are from OWFs either already operational or under construction, which on their own increase the existing mortality rate by 2.7%, 4.5% or 7.8%. The addition of collisions due to DEP and SEP represents a 14% increase in the annual collision rate on top of existing OWFs in all of these scenarios.

58. Using the as-built OWF scenarios at the worst case, between 11.6, 19.9 or 33.4 NNC SPA and Ramsar site Sandwich terns per year are predicted to die due to collisions with operational OWFs in the wider Wash area, depending on the avoidance rate used (0.993, 0.9883 or 0.980 respectively). This would represent a 1.2%, 2.0% or 3.4% increase in the existing mortality rate. Depending on the avoidance rate used, between 7.9, 13.4 or 22.9 collisions per year are from OWFs either already operational or under construction, which on their own increase the existing mortality rate by between 0.8%, 1.4% or 2.3%. The addition of collisions due to DEP and SEP represents a 46% increase in the annual collision rate on top of existing OWFs in all of these scenarios.

59. As predicted increases in baseline mortality of breeding adult Sandwich tern of in excess of 1% are predicted, a PVA has been produced for this species to assess the possibility of significant effects on the population at the colony level. The initial mortality levels simulated by the PVA ranged from 10 to 210, in increments of 25 birds. This range was selected as a range of mortalities covering the predicted project alone impacts of DEP and SEP, plus the in-combination impacts with other OWFs. Impacts were calculated as relative harvest of breeding adults. Full details of the model will be presented in the PEIR, **Appendix 13.1 Offshore Ornithology Technical Report**.

60. Scenarios A, B, C and D of the PVA produced for this assessment considers an initial annual mortality of 10, 35, 60 and 85 birds respectively (**Table 3-13**), which enable comment on the potential effect of these mortality levels on the NNC SPA and Ramsar site Sandwich tern population.

Table 3-13: Sandwich Tern PVA Outputs (CPGR and CPS) for Four Scenarios (Initial Mortality of 10, 25, 60 and 85 Birds per Year). Impacts Decrease Proportionally to Population Size

Year	A (10)		B (25)		C (60)		D (85)	
	CPGR	CPS	CPGR	CPS	CPGR	CPS	CPGR	CPS
0	-	-	-	-	-	-	-	-

Year	A (10)		B (25)		C (60)		D (85)	
	CPGR	CPS	CPGR	CPS	CPGR	CPS	CPGR	CPS
5	0.999 (0.995 - 1.003)	0.995 (0.974 - 1.015)	0.996 (0.992 - 1.000)	0.980 (0.960 - 1.001)	0.993 (0.989 - 0.997)	0.966 (0.946 - 0.986)	0.990 (0.986 - 0.994)	0.952 (0.931 - 0.971)
10	0.999 (0.996 - 1.002)	0.988 (0.959 - 1.018)	0.996 (0.993 - 0.999)	0.960 (0.929 - 0.989)	0.993 (0.990 - 0.996)	0.931 (0.901 - 0.962)	0.990 (0.987 - 0.993)	0.904 (0.876 - 0.934)
15	0.999 (0.996 - 1.002)	0.983 (0.945 - 1.023)	0.996 (0.993 - 0.999)	0.941 (0.903 - 0.981)	0.993 (0.990 - 0.996)	0.899 (0.861 - 0.943)	0.990 (0.987 - 0.993)	0.860 (0.822 - 0.898)
20	0.999 (0.996 - 1.002)	0.976 (0.929 - 1.031)	0.996 (0.993 - 0.998)	0.920 (0.875 - 0.969)	0.993 (0.990 - 0.995)	0.867 (0.821 - 0.912)	0.990 (0.987 - 0.993)	0.818 (0.772 - 0.863)
25	0.999 (0.995 - 1.001)	0.971 (0.910 - 1.032)	0.996 (0.993 - 0.999)	0.903 (0.844 - 0.965)	0.993 (0.990 - 0.996)	0.838 (0.782 - 0.893)	0.990 (0.987 - 0.992)	0.778 (0.724 - 0.828)

61. The CPGR for Scenarios A, B, C and D respectively is 0.999, 0.996, 0.993 and 0.990. In other words, the growth rate of the population compared with the baseline scenario is reduced by 0.1%, 0.4%, 0.7% and 1.0% due to these potential impacts. In the context of a population that has experienced a mean annual growth of 8.5% between 2010 and 2020, it is not considered that a reduction in the growth rate of the magnitude anticipated in Scenarios A, B or C represents a substantial effect on the population, though it is acknowledged that this may not be the case with respect to Scenario D.

62. The CPS for these PVA scenarios suggest that relatively large impacts on the population may be possible after 25 years of OWF operation. The counterfactuals range from 0.971 for Scenario A, to 0.778 for Scenario D. The discussion in the PEIR **Appendix 13.1 Offshore Ornithology Technical Report** indicates that for a number of reasons, this metric may be producing population level effect predictions that are excessively precautionary.

63. The use of consented OWF designs in the calculation of in-combination collision risk results in a substantially higher number of predicted collisions than the as-built scenarios, and clearly, the use of such designs predicts greater chances of substantial effects on the NNC SPA and Ramsar site Sandwich tern population. In particular, it is considered possible that an avoidance rate of 0.980, AEOI of the NNC SPA and Ramsar site are possible, though at the higher avoidance rates of 0.9883 and 0.993, this is considered unlikely. The use of consented OWF parameters also reduces the percentage increase in collision mortality caused by the operation of DEP and SEP relative to the as-built scenario (14% increase versus 46% increase), so it could be argued that the majority of impacts are being caused by other OWFs and not DEP and SEP.

64. When using the as-built OWF designs, it is concluded that no AEOI is likely at any of the avoidance rates under consideration.

65. In summary therefore, to produce a scenario that may result in an AEOI of the Sandwich tern population of the NNC SPA and Ramsar site, consented OWF designs need to be combined with an avoidance rate (0.980) that is considered to be low, relative to that previously used in a similar assessment on this colony (0.9883, DECC 2012), or that estimated from recently, locally collected data (0.993, Harwood et al. 2018). It is acknowledged however that model error is unaccounted for in these avoidance rates, but despite this, on balance, it is concluded that predicted mortality due to in-combination operational phase collision at OWFs within the wider Wash area would not adversely affect the integrity of the NNC SPA and Ramsar site.

3.3 Initial Review of Potential Sandwich Tern Compensatory Measures – 2013 DEFRA report

66. Possible measures that could improve the conservation status of UK seabird populations are set out in a report to Defra (Furness et al. 2013). The measures presented, in the form of a series of 'management options' were informed by a review of the main factors contributing to reduced productivity at monitored colonies in Britain and Ireland between 1986 and 2006. These are summarised for Sandwich tern in **Table 3-14**, including comment as to whether each measure might be suitable for NNC SPA. The list of measures identified for Sandwich tern by Furness et al. 2013 is considered to remain comprehensive for this purpose.

67. This initial assessment of suitability draws on the latest information available for the colony at NNC SPA, including that derived from the Sandwich tagging programme undertaken by Equinor since 2016 as part of the Ornithological Monitoring Programme (OMP) for the existing Dudgeon offshore wind farm. The Dudgeon OMP tagging work, conducted at Scolt Head, has involved close working with the site management team at Natural England.

68. The options that are considered to be potentially suitable are discussed further in **Section 3.4**.

Table 3-14: Suitability of Possible Measures to Improve Conservation Status of Sandwich Tern at NNC SPA (Adapted from Furness et al. 2013)

Possible measure	Method	Comment on suitability at NNC SPA
Prey enhancement	Closure of sandeel and sprat fisheries close to breeding colonies	Potentially suitable – Sandwich tern is considered to be a specialist on forage fish. There is evidence that breeding success is influenced by forage fish abundance. There is evidence that forage fish stocks would be larger if fishing mortality was reduced.
Predator control / mortality reduction	Eradicate mink	Not suitable – not a pressure at NNC SPA
	Eradicate feral cats	Not suitable – not a pressure at NNC SPA
	Eradicate rats	Not suitable – not a pressure at NNC SPA
	Exclude foxes	Potentially suitable – predation by foxes has been considered to affect breeding success at colonies in NNC SPA and to result in declines in breeding numbers when fox activity is high.
	Control stoats	Not suitable – not a pressure at NNC SPA
	Exclude large gulls from nesting close to colonies	Potentially suitable – it is considered that large numbers of gulls may influence colony settlement in spring by Sandwich terns at NNC SPA.
Productivity improvement	Protection of colonies from flooding or engineering of new nesting habitat in safer locations	Potentially suitable – Sandwich tern breeding success can be affected by flooding, and colony sites may become less suitable over time as vegetation develops, so engineering may allow breeding under optimal conditions.

3.4 Potential DEP & SEP NNC SPA Compensatory Measures

69. The options considered to be potentially suitable for NNC SPA are investigated further in this section in order to identify and where possible rank the options according to key factors including chance of success, cost-effectiveness, feasibility and practicality. A total score is provided only to give an indication of the overall suitability of each measure. Those considered to be the most appropriate options across the range of factors considered are taken forward to the short list.

Table 3-15: Ranking of Long List of Potential DEP & SEP Compensatory Measures (1 = Low Score, 3 = High Score)

Possible measure and method	Delivery mechanism/s	Score and rationale				Total score	Option taken forward to short list?
		Chance of success	Cost-effectiveness	Practicality	Deliverability		
Prey enhancement: closure of sandeel and sprat fisheries close to the breeding colony	Exclude fishing from a defined area	2 Food shortage is implicated as a cause of reduced productivity at some colonies in some years (Mitchell et al. 2004, Frederiksen and Wanless 2006, Furness et al. 2013, Stienen et al. 2015, Fijn et al. 2017). Frederiksen and Wanless (2006) concluded “Sandwich terns may have been affected by reduced sandeel availability during the 1990s in a similar way to black-legged kittiwakes”. Woodward et al. (2019) list the foraging range of breeding Sandwich terns as mean 9km, mean maximum 34.3km, maximum 80km. However, these distances are likely to	1 Uncertain / not defined. Costs potentially very high. More appropriate as strategic approach by Government and Industry	1 Issues with scale – more suitable as a long term strategic, ecosystem-wide measure covering the potential impacts of multiple wind farms. Issues with timeframes – colony effects unlikely to become	2 No mechanism exists for the delivery of fisheries management areas for the purposes of compensation. Government intervention required.	6	No

Possible measure and method	Delivery mechanism/s	Score and rationale				Total score	Option taken forward to short list?
		Chance of success	Cost-effectiveness	Practicality	Deliverability		
		apply more along the coast than directly out to sea, given the preference of UK breeding Sandwich terns to remain near the coast, so closure of sandeel and sprat fishing within 60 km of the colony should increase productivity and adult survival.		apparent for >5 years.			
	Fishery quota purchase	1 Sandeel quota is not held by UK fishing vessels. The ability of the Applicant to purchase fishing quotas would also be dependent on fishermen with appropriate quotas being willing to sell.	1 Uncertain	1 Unlikely to be possible	1 Uncertain	4	No
Predator control / mortality	Fencing to exclude foxes and other	3	2 Expensive, but effective	3 Appropriate for tern colonies on	2 Sites appear suitable but	10	Yes

Possible measure and method	Delivery mechanism/s	Score and rationale				Total score	Option taken forward to short list?
		Chance of success	Cost-effectiveness	Practicality	Deliverability		
reduction: exclude foxes	mammal predators	Known to be successful (Furness et al. 2013)	(Furness et al. 2013)	open coastal habitat (Furness et al. 2013)	implementation would require agreement of landowners		
Predator control / mortality reduction: exclude large gulls from nesting close to colonies	Control of large gulls to deter from use of the area	1 Gull impacts on terns tend to be low, infrequent/sporadic and difficult to assess, and gull movements/activity can be infrequent/sporadic/opportunistic, so difficult to control	1 Uncertain	2 May be possible to obtain a licence from Natural England to control gulls, but it is not clear that attempts at such control would be effective in reducing gull presence	2 Implementation would require agreement of landowners which may be difficult if it would involve killing gulls	6	No
Productivity improvement:	Engineering of colony area	2	2	2	2	8	Yes

Possible measure and method	Delivery mechanism/s	Score and rationale				Total score	Option taken forward to short list?
		Chance of success	Cost-effectiveness	Practicality	Deliverability		
protection of colonies from flooding or engineering of new nesting habitat in safer locations	during winter to prepare for breeding season by reducing any incursion of vegetation and reducing risk of flooding	Believed to be practical and successful (Furness et al. 2013)	Expensive, but effective (Furness et al. 2013)	Likely to be appropriate for tern colonies on open coastal habitat (Furness et al. 2013)	Sites appear suitable but implementation would require agreement of landowners		

3.5 Short Listed DEP & SEP NNC SPA Compensatory Measures

3.5.1 Predator control / mortality reduction: exclude foxes

3.5.1.1 Overview

70. Sandwich terns are highly vulnerable to mammal predators and declines at colonies are most often related to an increase in predator access, especially to foxes, but also rats, stoats and American mink. Predators can cause complete abandonment of a colony, or periodic breeding failure (Mitchell et al. 2004).

3.5.1.2 Delivery Mechanism

71. Foxes can be controlled on small islands by shooting, although recolonisation from the mainland may be an issue for islands situated within 1 or 2km of the mainland. Fencing of colonies to exclude foxes would allow Sandwich tern productivity to increase at colonies where this predator is present. In the UK, some examples of using electric fences to exclude foxes from colonies have been successful, but electric fences are not fully effective in excluding predators and require frequent maintenance. A more expensive but more effective alternative is the use of predator-proof fences, as deployed in Hawaii at Ka' ena Point Natural Area Reserve (Young et al. 2012). These 2 m tall fences prevent predators (including rats and mice) from entering the protected area. Predators (in their case dogs, cats, mongoose, rats and mice) were eradicated within the enclosed 20 ha (which took three months to complete for all predators except mice which were eradicated within an additional six months). This was the first predator proof fence constructed in the United States at the time of its completion (Young et al. 2012) but the same approach has been used extensively in New Zealand, and has been used at a few sites in Europe, including the Azores where it has been deployed to exclude predators from ground-nesting seabird colonies (Furness et al. 2013, RSPB 2020, Xcluder 2020). Such completely predator-proof fencing may be unnecessary to protect colonies just from foxes, but might be especially appropriate for colonies subject to predation by rats or mink as well as by foxes.

3.5.1.3 Spatial Scale

72. Requires a fence to be erected around the area of open coastal habitat used for nesting by Sandwich terns. The fence should be set back from the colony edge so that it does not influence flight lines and behaviour of nesting birds, but the spatial scale is local to the specific nesting habitat. There may be scope for fencing to protect more than one colony.

3.5.1.4 Timescale

73. The fence should be constructed during October-February, to have work completed at a time of year when Sandwich terns are absent from the area. Construction could be completed in one winter, and it should be possible to do this before the wind farm construction begins. The fence will be effective from construction, so will enhance breeding success of the terns from its first season.

3.5.1.5 Options for Monitoring

74. Sandwich tern breeding numbers and breeding success are routinely monitored using standard methods established by The Seabird Group. That monitoring should continue on an annual basis to demonstrate the efficacy of predator exclusion in this particular case.

3.5.1.6 Feasibility

75. This is feasible, providing agreement can be made with landowners to set up fences around Sandwich tern nesting habitat at suitable sites within NNC SPA. During the 1970s, Sandwich terns at NNC SPA (which was not in existence at that time) mostly nested at Stiffkey/Holkham or Scolt Head. Blakeney Point was colonised from the late 1970s and the Stiffkey/Holkham site was abandoned, except briefly in 2001-2004. There may be merit in fencing more than one colony area, in order to allow terns to move between sites if they wish. Although the Stiffkey/Holkham site has not been used for many years, it might be worth considering whether a third site (i.e. in addition to Blakeney Point and Scolt Head) might be useful to give the terns greater choice of predator-free nesting areas.

3.5.2 Productivity Improvement: Protection of Colonies from Flooding or Engineering of New Nesting Habitat in Safer Locations

3.5.2.1 Overview

76. NNC SPA Site Improvement Plan states “Investigate the options for adaptive site management in light of ecological changes likely to occur due to increased frequency and duration of saline inundation”. It is well known that Sandwich terns prefer to nest on areas of flat bare coastal habitat, and that these sites can be at risk of flooding and erosion by tidal inundation and by intense rainfall and runoff. Sandwich terns may also abandon nesting areas if too much vegetation develops on the nesting area. Long-term breeding success of Sandwich terns at NNC SPA could be improved by engineering works that maintain Sandwich tern preferred nesting habitat in optimal condition, engineered to minimize risk of flooding and erosion and to minimize risk of excessive vegetation development on the nesting area.

3.5.2.2 Delivery Mechanism

77. Engineering work should be repeated at intervals (probably every five years or so, but in an adaptive manner depending on local conditions) in order to strengthen the protection of the nesting areas against flooding, erosion and vegetation increase.

3.5.2.3 Spatial Scale

78. Work would be limited to the immediate surroundings of the Sandwich tern nesting areas, with engineering design based on local knowledge of the risks to these sites posed by flooding, erosion and vegetation succession.

3.5.2.4 Timescale

79. Engineering work should be carried out during October-February, to have work completed at a time of year when Sandwich terns are absent from the area, and should be repeated at intervals (probably every five years or so, but in an adaptive manner depending on local conditions).

3.5.2.5 Options for Monitoring

80. Sandwich tern breeding numbers and breeding success are routinely monitored using standard methods established by The Seabird Group. That monitoring should continue on an annual basis to demonstrate the efficacy of predator exclusion in this particular case.

3.5.2.6 Feasibility

81. Sites in NNC SPA appear suitable for such enhancement, but this would require agreement of local landowners. Success would also depend on the local expertise of National Trust and Natural England staff, especially site wardens with experience of the extent and location of risks to the tern habitat areas.

3.6 Proposed Approach to Delivery of Compensation

3.6.1 Next steps

82. [Section describing approach to be developed once preferred measure/s selected following consultation]

3.6.2 Monitoring

83. [Proposals to monitor the effectiveness of the compensatory measure/s to be developed once preferred measure/s selected following consultation]

3.6.3 DCO Condition

84. [Subject to preferred measure/s]

3.7 NNC SPA Summary

85. Prey enhancement through closure of sandeel and sprat fisheries within 60km of the colony should increase productivity and adult survival. However, there are very clear challenges with the cost-effectiveness, practicality and deliverability of this as a developer led measure. As such this measure would have merit taken forward as a strategic approach led by UK Government to provide compensation on behalf of industry and UK society by establishing no-take zones that will allow prey species stock biomass to recover.

86. Alternatively, predator control / mortality reduction and productivity improvement have been identified as potential developer led, local measures. Mortality reduction could be achieved through the exclusion of foxes, with the potential to consider whether measures at a third site (i.e. in addition to Blakeney Point and Scolt Head) might be useful. Opportunities for productivity improvement exist either through the protection of colonies from flooding or engineering of new nesting habitat in safer locations, although the feasibility of such measures would need to be further developed through discussion with landowners and site managers.

4 Flamborough and Filey Coast SPA

4.1 Site Description

4.1.1 Overview

87. Flamborough Head and Bempton Cliffs was classified as a Special Protection Area (SPA) on 5 March 1993, with breeding kittiwake the sole feature of that SPA. The site was then extended and renamed Flamborough and Filey Coast SPA (FFC SPA) on 23 August 2018. Features of the new site are breeding kittiwake, gannet, common guillemot, and razorbill, and also the breeding seabird assemblage. The revised SPA covers an area of 7,857.99ha of the Yorkshire coast between Bridlington and Scarborough (Natural England 2018). The SPA is in two sections: the southern section extends north from South Landing around Flamborough Head to Speeton; the northern section covers the peninsula of Filey Brigg before extending north west to Cunstone Nab. The seaward boundary extends 2km throughout the two sections of the site into the marine environment, running parallel to the landward boundaries to include the adjacent coastal waters. The SPA includes the RSPB reserve at Bempton Cliffs, the Yorkshire Wildlife Trust Flamborough Cliffs Nature Reserve and the East Riding of Yorkshire Council Flamborough Head Local Nature Reserve. The predominantly chalk cliffs of Flamborough Head rise to 135 metres and have been eroded into a series of bays, arches, pinnacles and gullies. The cliffs from Filey Brigg to Cunstone Nab are formed from various sedimentary rocks including shales and sandstones. The adjacent sea out to 2km off Flamborough Head as well as Filey Brigg to Cunstone Nab is characterised by reefs supporting kelp forest communities in the shallow subtidal, and faunal turf communities in deeper water. The southern side of Filey Brigg shelves off gently from the rocks to the sandy bottom of Filey Bay. This site does not support any priority habitats or species (Natural England 2018).

88. The citation (Natural England 2018) states that FFC SPA qualifies under Article 4.2 of the Birds Directive (2009/147/EC) by supporting over 1% of the biogeographical populations of four regularly occurring migratory species and a breeding seabird assemblage of European importance: kittiwake 44,520 pairs (4 year average 2008-2011); gannet 8,469 pairs (2008-2012); common guillemot 41,607 pairs (2008-2011) and razorbill 10,570 pairs (2008-2011), and a breeding seabird assemblage of 216,730 individual seabirds (average 2008-2012, but species composition not listed explicitly so it is unclear whether the assemblage includes species that are additional to the four named species).

4.1.2 Conservation Objectives

89. The Conservation Objectives for the site are to ensure that, subject to natural change, the integrity of the site is maintained or restored as appropriate, and that the site contributes to achieving the aims of the Birds Directive, by maintaining or restoring:

- The extent and distribution of the habitats of the qualifying features;

- The structure and function of the habitats of the qualifying features;
- The supporting processes on which the habitats of the qualifying features rely;
- The populations of each of the qualifying features; and
- The distribution of the qualifying features within the site.

90. Natural England (2020) has stated the target is to restore the size of the kittiwake breeding population at a level which is above 83,700 breeding pairs, whilst avoiding deterioration from its current level as indicated by the latest mean peak count or equivalent.

4.1.3 Interest Feature – Breeding Kittiwake

91. The trend in the kittiwake population for this site has been subject to discussion and disagreement between the world's leading expert on kittiwake ecology (John Coulson) and the Statutory Nature Conservation Bodies (SNCBs). There were 19,000 pairs in 1959, and 30,800 pairs in 1969 (Lloyd et al. 1991). At the time of classification of the Flamborough Head and Bempton Cliffs SPA, it was thought to support 83,370 breeding pairs of kittiwakes (based on a count in 1987). However, there were 42,582 pairs in 2000 and 37,617 pairs in 2008 (JNCC 2020). There is uncertainty as to whether there were ever as many as 83,370 pairs of kittiwakes at this site; this number has been challenged repeatedly (Coulson 2011, 2017), most recently by noting that this colony should have been increasing in numbers based on monitoring data on its productivity, so the apparent decline by 50% from 1987 to 2000 is contrary to what is understood of the biology of this species. Coulson commissioned the 1987 count which was sent to him by RSPB, but no details of the count methodology that were followed in 1987 have ever been published. Coulson has suggested that the anomalous high count in 1987 may have been because numbers were expressed as individuals rather than pairs, and then mistakenly recorded as pairs. That would fit well with previous and subsequent counts which have consistently been around 40,000 to 50,000 pairs (see **Plate 4-1** and **Plate 4-2**). The apparent decline from 83,370 pairs in 1987 to 37,617 pairs in 2008 does not correspond with population trajectories based on the influence of productivity on population change (Coulson 2017). As predicted by Coulson (2017) based on local breeding success data, recent counts by the RSPB show a small increase in kittiwake breeding numbers in the years since 2008. Babcock et al. (2016) counted 51,001 Apparently Occupied Nests (AONs i.e. pairs) in FFC SPA in 2016. Aitken et al. (2017) counted 51,535 AONs (pairs) in FFC SPA in 2017. Inconsistent treatment of seabird count data and count units for FFC SPA is not unprecedented. For example, Natural England converted a single count of 980 individual puffins on land in 2008 (survey date not stated) to 490 pairs of puffins in the pSPA Departmental Brief, presumably assuming that the number of breeding pairs would be half the number of adults counted on land. They then changed this to 980 breeding pairs post-consultation, assuming a 1:1 ratio rather than a 2:1 ratio (Natural England 2015).

92. According to Natural England (2020) “The original citation for Flamborough Head and Bempton Cliffs SPA specifies that the site supported 83,700 pairs of breeding kittiwake in 1987. The current figures clearly indicate a major decline in numbers since this time. At present, it is unclear why this decline has occurred, although evidence suggests that reductions in the availability of the kittiwakes preferred prey species (sandeels) has also reduced kittiwake productivity”. This statement is inaccurate. Sandeel total stock biomass in the Dogger Bank stock (ICES area 1r) averaged almost 1,000,000 tonnes in 1984-2002, and did not show any significant reduction in biomass during that period (ICES 2020), whereas after 2003 the biomass fell to an average of only about half that level in 2003-2018 (ICES 2020), so decline in sandeel availability occurred after 2000, not before. Furthermore, kittiwake productivity at FFC SPA averaged around 1.2 chicks per pair in 1986 to 1990 (Carroll et al. 2017), one of the highest levels of breeding success recorded in any kittiwake colony in the British Isles over an extended period (Coulson 2011), and therefore likely to result in growth in breeding numbers by providing a strong attraction to potential recruits (Monnat et al. 1990, Cadiou et al. 1994). The high breeding success at FFC SPA in 1986-1990 is incompatible with any mechanism explaining decline as a result of reduced breeding success due to scarcity of sandeels. There is evidence that breeding success of kittiwakes at FFC was reduced by decline in sandeel abundance during the early 2000s when sandeel biomass did fall (Carroll et al. 2017), but there is no evidence to suggest scarcity of sandeels before the late 1990s and early 2000’s (ICES 2020). Since 2002, sandeel abundance has remained low, and breeding success of kittiwakes at FFC SPA has remained lower than in the period 1986-1990.

93. The trend in breeding numbers of kittiwakes at FFC SPA is shown in **Plate 4-1** and **Plate 4-2**, with and without the anomalous count of 1987 excluded.

Plate 4-1: Number of Pairs (AONs) of Kittiwakes at Flamborough and Filey Coast in National Surveys and Counts at FFC SPA, Excluding the Disputed Count from 1987, with Best Linear Trend Line Fitted

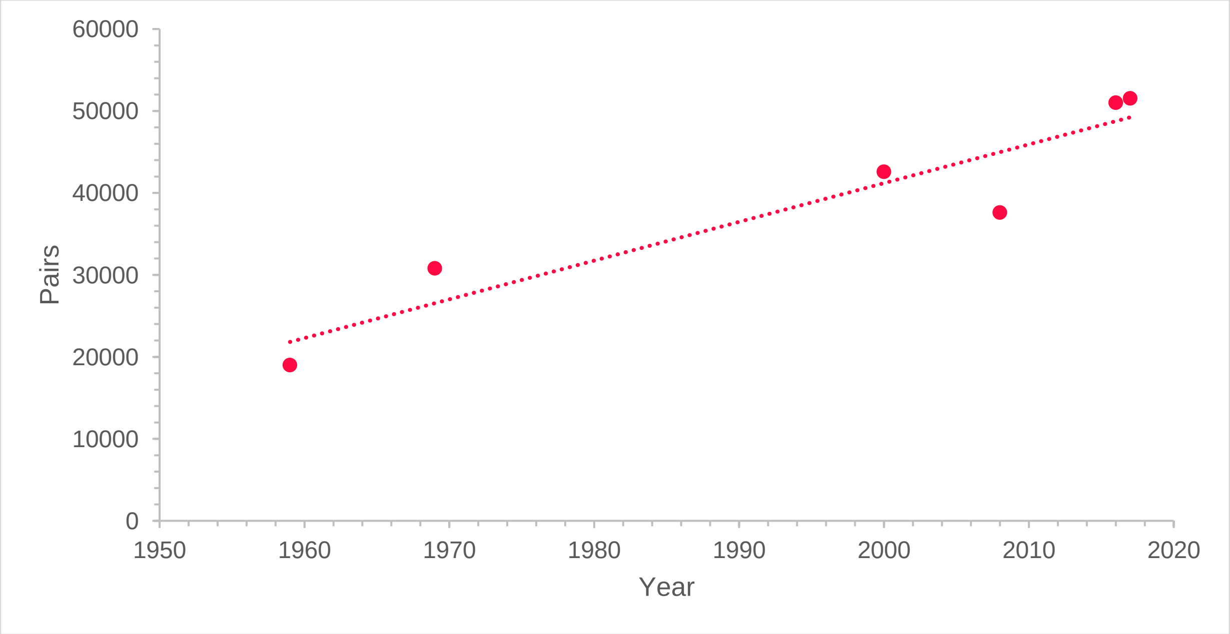
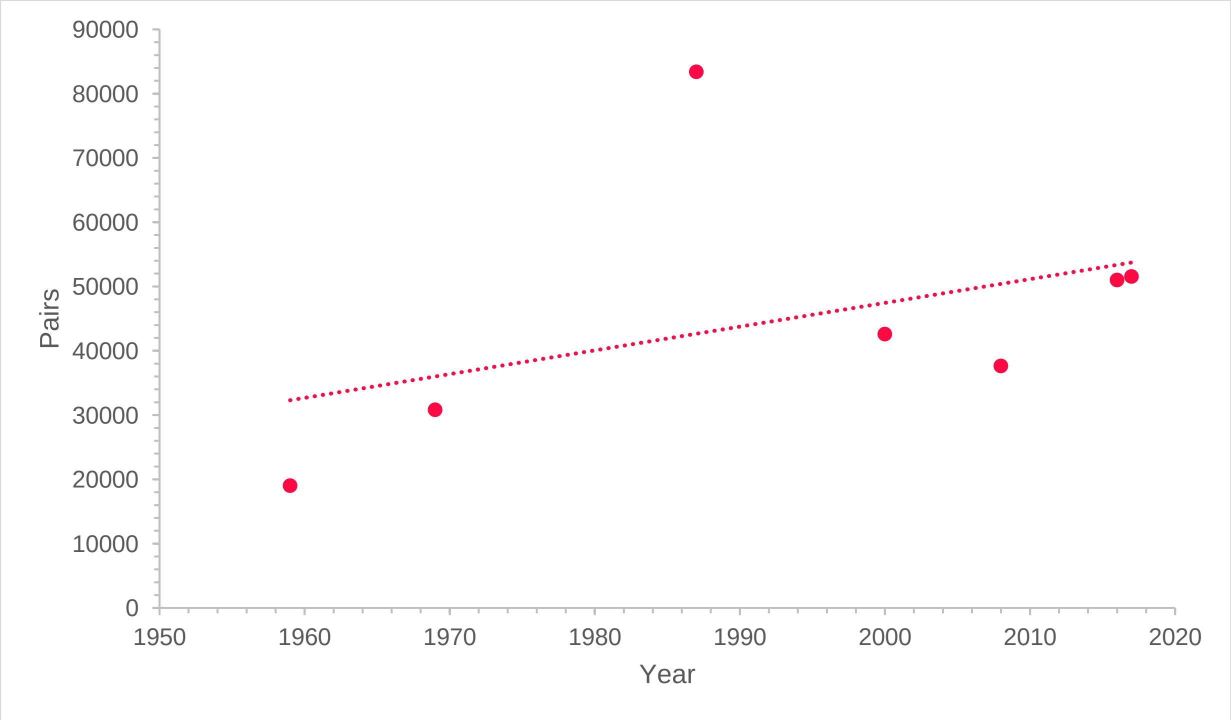
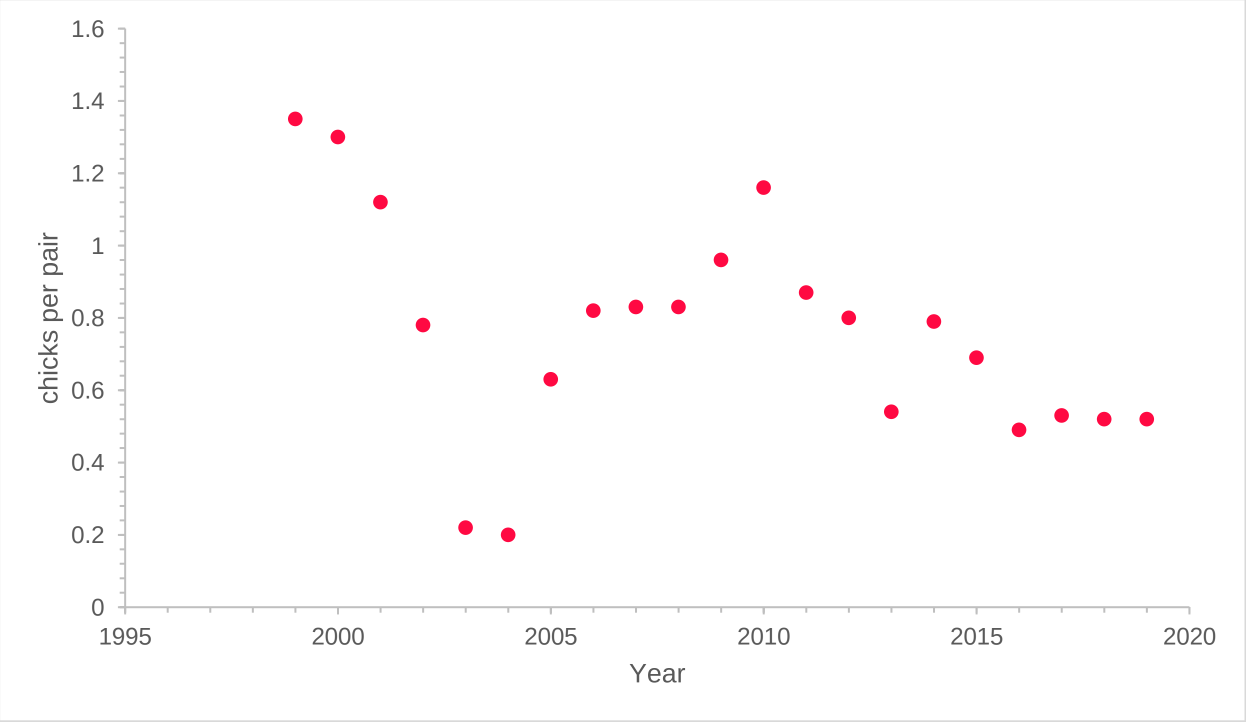


Plate 4-2: Number of Pairs (AONs) of Kittiwakes at Flamborough and Filey Coast in National Surveys and Counts at FFC SPA, Including the Disputed Count from 1987, with Best Linear Trend Line Fitted



94. Breeding success of kittiwakes at FFC SPA has declined in recent years (**Plate 4-3**). It fell from an average of 1.2 chicks per pair in 1999-2001 to an average of just over 0.8 chicks per pair in 2006-2011, to around 0.5 chicks per pair in 2016-2019 (RSPB Annual Reports). This decline coincides with decline in sandeel abundance: total stock biomass in ICES area 1r (which includes the foraging grounds of kittiwakes breeding at FFC SPA) fell from an average of 995,624 tonnes in 1984-2002 to an average of 574,771 tonnes in 2003-2012 and fell further to an average of 460,023 tonnes in 2013-2018 (ICES 2020). The only year since 2000 in which breeding success exceeded 1 chick per pair (2010) was also the one and only year with anomalously high sandeels stock biomass (1.6 million tonnes) due to one year of exceptionally high recruitment (see also **Plate 4-6**). However, that was a short-lived peak of sandeel abundance, in part because higher catches were taken from the stock by the fishery in 2010-2011 (ICES 2020).

Plate 4-3: Breeding Success of Kittiwakes (Chicks per Pair) at FFC SPA (Data from RSPB Annual Reports)



95. There are 29 sites in Scotland with breeding kittiwake listed in the citation as a SPA feature. There are two in England (Farne Islands and FFC), one in Wales, and one in Northern Ireland. In the most recent assessment of site condition, the conservation status of the breeding kittiwake feature at four sites in Scotland was classified as Favourable Maintained, but was classified as Unfavourable at 25 sites. Declines have been especially large in Shetland and Orkney, where SPA populations have fallen by 90% since designation. Overall, the Natura suite for breeding kittiwake should be considered at present to be in Unfavourable conservation status. In contrast, breeding numbers at FFC SPA increased from 44,520 at classification to 51,535 pairs in 2017 (Aitken et al. 2017), an increase of 16%. This makes FFC SPA by far the largest kittiwake colony in the British Isles, and an increasingly important proportion of the entire kittiwake breeding population in the British Isles. In 1969, FFC SPA held about 30,800 pairs of kittiwakes from a population of 470,388 pairs in Britain and Ireland (Cramp et al. 1974), or 6.5% of the total. In 2000, FFC SPA held about 42,582 pairs of kittiwakes from a population of 415,995 pairs in Britain and Ireland (Mitchell et al. 2004), or 10% of the total. Now, FFC SPA holds about 51,535 pairs from a total in Britain and Ireland that is probably around 200,000 to 250,000 pairs based on the observed rate of decline and most recent colony counts (JNCC 2020), so FFC SPA now holds probably over 20% of the current total in Britain and Ireland.

4.2 Potential Impacts

96. The following sections provide a summary of the potential impacts on kittiwake at FFC SPA in order to help set the context for the discussion of potential compensatory measures that follows. All assessment outcomes at the time of writing are draft and may be subject to change.

4.2.1 Overview

97. The screening process undertaken in the development of the PEIR **ornithology** chapter has identified kittiwake as being of relatively high sensitivity to potential collision with operational offshore wind turbines at DEP and SEP. The species is considered to be insensitive to impacts relating to disturbance, displacement during any project phase, or any indirect impacts that may occur as a result of the construction, operation or decommissioning of DEP and SEP.

98. It is presumed that 100% of birds present at DEP and SEP during the breeding season are breeding adults from the FFC SPA and therefore 100% of all predicted impacts during the full breeding season (March to August) are attributable to this population.

99. Outside the breeding season, impacts on kittiwake have been compared to the appropriate Biologically Defined Minimum Population Size for the season in question. The relevant background population is considered to be the UK North Sea BDMPS, consisting of 829,937 individuals during autumn migration (August to December), and 627,816 individuals during spring migration (January to April) (Furness, 2015). During autumn and spring migration, 5.4% and 7.2% of collisions respectively are considered to affect birds from the SPA.

4.2.2 Quantification of Effect – Collisions

100. Potential collision risk for kittiwake and DEP and SEP was estimated using the Band (2012) collision risk model (CRM). Full details of the input parameters used will be provided in the PEIR **chapter** and accompanying **technical appendix**.

4.2.2.1 Project Alone

101. Seasonal and annual collision risk predictions for kittiwake at DEP, SEP, and DEP and SEP combined, apportioned to FFC SPA (means and upper and lower 95% confidence intervals), are shown in **Table 4-1**.

102. The worst case predicted annual mortality of kittiwakes at FFC, for DEP and SEP combined, is 19 (95% Confidence Intervals 2-71) birds (values rounded to the nearest integer). Assuming on a precautionary basis that all birds predicted to die from collisions are breeding adults, under all scenarios, the predicted increase in the annual baseline mortality is less than 1% (**Table 4-1**).

103. As predicted increases in baseline mortality of breeding adult kittiwakes of less than 1% are likely to be undetectable against natural variation, it is concluded that under all Project alone scenarios, predicted collision mortality of kittiwakes at DEP, SEP and DEP and SEP combined would not adversely affect the integrity of the FFC SPA.

Table 4-1: Predicted Seasonal and Annual Collision Mortality for Kittiwake at DEP and SEP Apportioned to FFC SPA

Collision Mortality[1]		Autumn Migration			Spring migration			Breeding			Annual		
Scenario		LCL[2]	Mean	UCL[2]	LCL	Mean	UCL	LCL	Mean	UCL	LCL	Mean	UCL
DEP	14MW	0.02	0.46	1.41	0	0.16	0.46	2.09	17.24	63.28	2.11	17.86	65.15
		Predicted increase in annual adult mortality rate[3]									0.01%	0.12%	0.43%
	26MW	0.01	0.18	0.55	0	0.06	0.18	0.62	6.73	24.68	0.63	6.97	25.41
		Predicted increase in annual adult mortality rate									0%	0.05%	0.1 %
SEP	14MW	0	0.10	0.59	0	0	0	0	0.89	4.84	0	0.99	5.43
		Predicted increase in annual adult mortality rate									0%	0.01%	0.04%
	26MW	0	0.04	0.23	0	0	0	0	0.35	1.92	0	0.39	2.15
		Predicted increase in annual adult mortality rate									0%	0%	0.01%
DEP and SEP	14MW	0.02	0.56	2.00	0	0.16	0.46	2.09	18.13	68.12	2.11	18.85	70.58
		Predicted increase in annual adult mortality rate									0.01%	0.13%	0.47%
	26MW	0.01	0.22	0.78	0	0.06	0.18	0.62	7.08	26.6	0.63	7.36	27.56

Collision Mortality[1]		Autumn Migration			Spring migration			Breeding			Annual		
Scenario		LCL[2]	Mean	UCL[2]	LCL	Mean	UCL	LCL	Mean	UCL	LCL	Mean	UCL
		Predicted increase in annual adult mortality rate									0%	0.05%	0.18%

1. Number of individuals at avoidance rates 0.987-0.991

2. LCL=Lower 95% confidence limit, UCL=Upper 95% confidence limit

3. With reference to baseline annual adult mortality rate 0.146

4.2.2.2 In-Combination

104. Based on the seasonal and annual collision mortality estimates used for OWFs included in the in combination assessment and the apportioning as described, the predicted annual collision mortality for kittiwake apportioned to the FFC SPA is 535 individual birds, of which DEP and SEP combined contribute 19 birds, 3.6% of the total. On a precautionary basis it is assumed for the purposes of this assessment that all birds are breeding adults from the SPA.

105. This level of change could affect the population status and further investigation of the population effects is therefore required.

106. The predicted in combination collision mortality for kittiwakes can be compared to a population model for the FFC SPA population developed for the Hornsea Project Three OWF (Niras and MacArthur Green 2018). The initial population size for the kittiwake model was the breeding population in 2008 (89,041 breeding adults) (MacArthur Green 2015).

107. Outputs from the models for the proposed 35 year operational period of DEP and SEP are presented for adult mortality levels which correspond most closely to the in combination mortality predictions (**Table 4-2**). For each adult mortality level, the table shows the predicted changes in median population growth rate calculated between year 5 and year 35, and the counterfactual or ratio of population size at year 35, for models including predicted mortality of adult kittiwakes from collision and displacement at OWFs (impacted populations), and models without predicted mortality (unimpacted populations) from Niras and MacArthur Green (2018). The changes in predicted growth rates and counterfactuals of population size are presented to illustrate the likely magnitude of change between impacted and unimpacted populations. The models are not intended to generate accurate predictions of future growth, which would require estimates of future changes in demographic parameters of the modelled population, for example in response to changes in prey abundance and climate (MacArthur Green 2015).

Table 4-2: Population Modelling Results for Kittiwake at Flamborough and Filey Coast: Counterfactuals of Population Growth Rate and Size for Models Including and Excluding Predicted Mortality from Collision and Displacement from OWFs.

Model	Adult mortality	Counterfactual metric (after 35 years)		Source table (Niras & MacArthur Green 2018)
		Growth rate	Population size	
Rate set 1, density independent	500	0.994	0.826	A2_5.1, 5.3
	550	0.994	0.810	
	500	0.999	0.953	A2_6.1, 6.3

Model	Adult mortality	Counterfactual metric (after 35 years)		Source table (Niras & MacArthur Green 2018)
		Growth rate	Population size	
Rate set 1, density dependent	550	0.999	0.958	
Rate set 2, density independent	500	0.994	0.827	A2_7.1, 7.3
	550	0.994	0.810	
Rate set 2, density dependent	500	0.999	0.950	A2_8.1, 8.3
	550	0.999	0.944	

108. It is considered that the counterfactuals of population growth rate are more informative and robust for the purposes of the assessment than those for the population size after 35 years (MacArthur Green 2019).

109. The maximum predicted reduction in the population growth rate of impacted populations, at a mortality of 550 breeding adults, was 0.06% (0.994) from the density independent models and 0.01% (0.999) from the density dependent models.

110. As noted previously, notwithstanding the contested count of 83,700 pairs in 1987, kittiwake breeding numbers at the FFC SPA have increased by 7% between 2000 and 2017 (JNCC 2020, Aitken et al. 2017), equivalent to 0.4% per year. This is consistent with the SPA conservation objective to maintain the population size subject to natural change. The density independent model predictions (likely to be more precautionary) for a total in combination adult mortality of 535, indicate a small risk that further population growth will occur at a slower rate; whereas the density dependent model indicates a negligible reduction in growth rate.

111. The predicted reduction in growth rate of 0.01 – 0.06% is not at a level which would trigger a risk of population decline but would potentially result in a small reduction in the current growth rate of the colony. Therefore, it is concluded there will be no adverse effect on the integrity of the FFC SPA kittiwake population from in-combination collisions from OWFs. Furthermore, with reference to the Secretary of State's recent HRA for Norfolk Vanguard (BEIS 2020a), it is arguable that the contribution of DEP and SEP to the in combination total is so small as to be considered *de minimis*.

4.3 Initial Review of Potential Kittiwake Compensatory Measures – 2013 DEFRA Report

112. Possible measures that could improve the conservation status of UK seabird populations are set out in a report to Defra (Furness et al. 2013). The measures presented, in the form of a series of 'management options' were informed by a review of the main factors contributing to reduced productivity at monitored colonies in Britain and Ireland between 1986 and 2006. These are summarised for kittiwake in **Table 4-3**. The list of measures identified for kittiwake by Furness et al. 2013 is considered to remain comprehensive for the purpose of informing the initial review of potential measures for DEP and SEP, however these are considered in the context of more recent literature in the sections that follow.

Table 4-3: Measures Listed in the Defra Report (Furness et al. *2013) to Improve the Conservation Status of Kittiwakes at Colonies Throughout the UK*

Measure	Suggested method	Suitability at FFC SPA
Prey recovery	Closure of sandeel and sprat fisheries	Highly suitable, as evidence shows consistently reduced breeding success in recent years, very low sandeel stock biomass in recent years, and an effect of sandeel fishing pressure reducing sandeel stock. There is little information on sprat in kittiwake diet at FFC, but sprat occurs in kittiwake diet at Lowestoft and has been suggested as a reason for high breeding success at that colony.
Predator control	Eradicate American mink	Not suitable. Due to the nature of the sheer cliffs, mammalian predation is not deemed to be a significant problem at this site (Natural England 2020).
	Eradicate feral cats	
	Eradicate rats	
	Exclude foxes	
	Exclude great skuas	Not suitable. Great skuas do not breed at or near this site (Furness 1987).
Improve nest sites	Construct artificial breeding sites	Not suitable at FFC SPA. However, construction of artificial breeding sites at suitable locations elsewhere on the east coast of England has been proposed by Hornsea Three (Ørsted 2020a,b,c,d,e,f), Norfolk Vanguard and Norfolk Boreas as possible compensation for impacts on FFC SPA kittiwakes if required, and that approach to compensation has been supported, with some reservations, by Natural England.

4.4 Potential DEP & SEP FFC SPA Compensatory Measures

113. From the evidence in Furness et al. (2013) in the context of FFC SPA and more recent literature, there are five potential compensatory measures that should be considered further:

- Habitat management plans to establish no-take zones for sandeel;
- Habitat management plans to establish no-take zones for sprat;
- Construction of new artificial breeding sites for kittiwakes at sea;
- Construction of new artificial breeding sites for kittiwakes on the coast; and
- Adjustment of existing artificial nest sites to enhance breeding success of kittiwakes.

114. These five measures are each considered in turn below.

4.5 Short Listed DEP & SEP FFC SPA Compensatory Measures

4.5.1 Habitat Management Plan to Establish No-Take Zones for Sandeel

115. During the breeding season, kittiwakes breeding at most colonies around the North Sea feed mainly on sandeels (Furness and Tasker 2000, Coulson 2011). Sandeel abundance strongly influences breeding success of kittiwakes (Furness and Tasker 2000, Frederiksen et al. 2004, Cury et al. 2011), and breeding success strongly influences whether kittiwake colonies increase or decrease in breeding numbers (Monnat et al. 1990, Cadiou et al. 1994, Coulson 2011, 2017). In Shetland, kittiwake breeding success, and breeding numbers, decreased dramatically after the collapse of the Shetland sandeel stock (Furness and Tasker 2000). Kittiwake breeding success has also been affected at the Isle of May, off east Scotland, when the sandeel stock in that area (which is distinct from the sandeel stocks at Shetland or in the southern North Sea; Frederiksen et al. 2005, ICES 2019, Olin et al. 2020) was heavily fished (Frederiksen et al. 2004). Sandeels (specifically *Ammodytes marinus*) are the target of what has been the largest single-species fishery in the North Sea over recent decades. Kittiwakes at FFC SPA forage over a large area from that colony, and their foraging area includes some of the most important sandbanks supporting high densities of sandeels and the sandeel fishery (Carroll et al. 2017). There is strong evidence that the sandeel fishery has caused depletion of sandeel biomass in this region (Lindegren et al. 2018), and that reduced abundance of sandeels as a result of the high fishing effort on sandeels has led to reduced breeding success of kittiwakes at FFC SPA (Carroll et al. 2017). Reducing the level of fishing effort on sandeels, or closing the fishery in waters close to the colony, would, therefore, represent mechanisms to improve breeding success of kittiwakes at that colony by making it possible for the biomass of the sandeel stock to recover from the high fishing mortality that has been imposed in recent decades. Such reduction would be anticipated to lead to rapid, though probably incomplete, recovery of sandeel abundance (Lindegren et al. 2018). Sandeel is a short-lived fish which starts to breed when only 1 or 2 years old, with high reproductive potential, and since kittiwakes will feed on all age classes of sandeels but especially on 1 and 2 year old sandeels, the increase in sandeel abundance would be likely to influence kittiwake breeding success with a time lag of only 1 or 2 years.

116. Frederiksen et al. (2004) showed that breeding success of kittiwakes at the Isle of May (part of Forth Islands SPA) was on average 0.5 chicks per pair lower during years when sandeel fishing occurred in the area than it was in years with no sandeel fishing. A decision was taken to close an area to sandeel fishing (the 'sandeel box' off the east of Scotland) because of persistent low breeding success of kittiwakes indicative of the poor condition of the sandeel stock in the area. The consequence of that closure was monitored. Closure of the fishery resulted in an increase in sandeel stock biomass (Greenstreet et al. 2006) and an increase in kittiwake breeding success at colonies within the closed area compared to those outside (Daunt et al. 2008, Frederiksen et al. 2008), providing experimental evidence for the mitigation of fishery impact by closing the fishery. Recovery of sandeel abundance in the closed area has led to the sandeel fishing industry seeking the opportunity to resume fishing within the closed area, but until now the regulator has retained this closed box, although fishing for sandeels has occurred right up to the offshore (eastern) edge of the closed box.

117. Closure of the sandeel fishery off east Scotland also altered the age structure of the sandeel population. When the stock was heavily fished, very few sandeels lived beyond two years old, resulting in high variability on stock abundance from year to year depending on the highly variable level of production of young fish. When the fishery was closed, sandeels tended to live longer, with large cohorts remaining in the stock for up to six years (Peter Wright, pers. comm.). The longer life expectancy of sandeels when not subject to fishing not only increases mean biomass of the stock, but also reduces variability in abundance driven by variable recruitment. This in turn will also be beneficial to kittiwake breeding success, by ensuring that even if recruitment is poor, the biomass of the stock is buffered by presence of several older age classes of fish.

118. The abundance of sandeels in ICES area 4 (which includes the sandeel no-take box off east Scotland) declined during 1993-2001 (**Plate 4-4**). However, after the closure of the sandeel fishery off east Scotland, this stock eventually recovered (**Plate 4-5**).

Plate 4-4: Abundance (Total Stock Biomass in Tonnes) of Sandeels in ICES Area 4 (which Includes the No-Take Zone off East Scotland that was Established in 2000) in the Period 1993 to 2001. Data from ICES (2020)

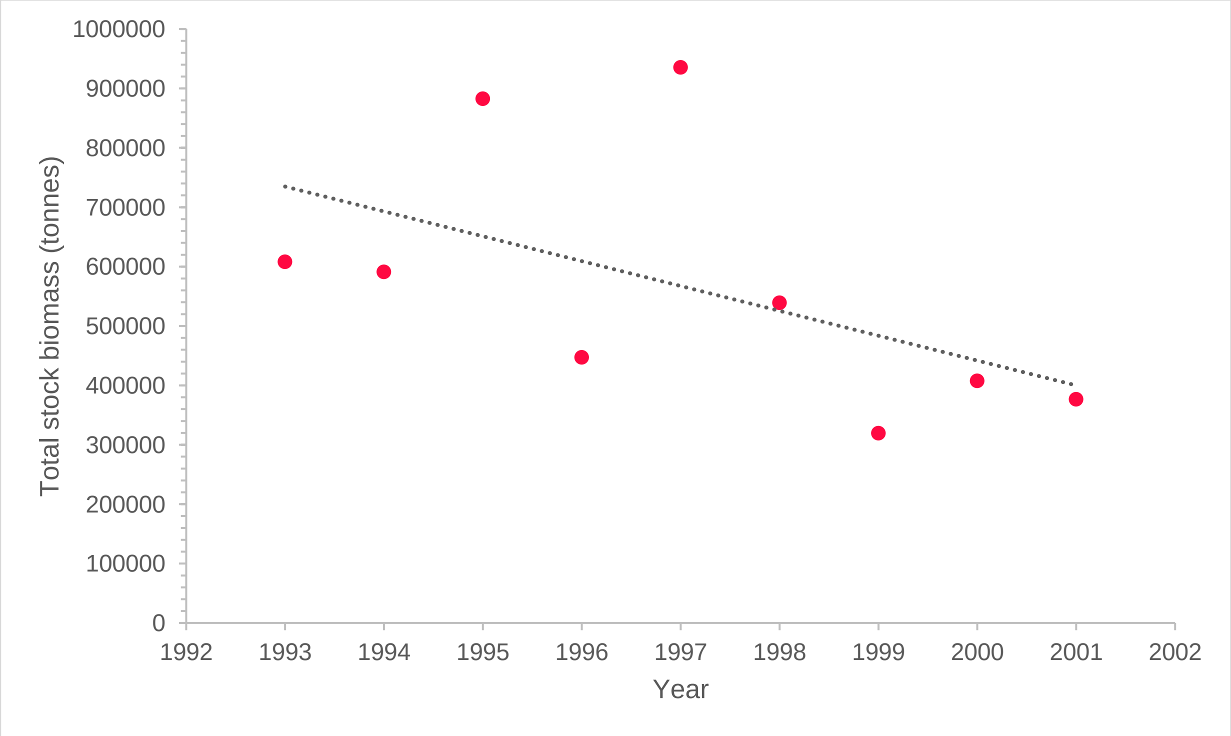
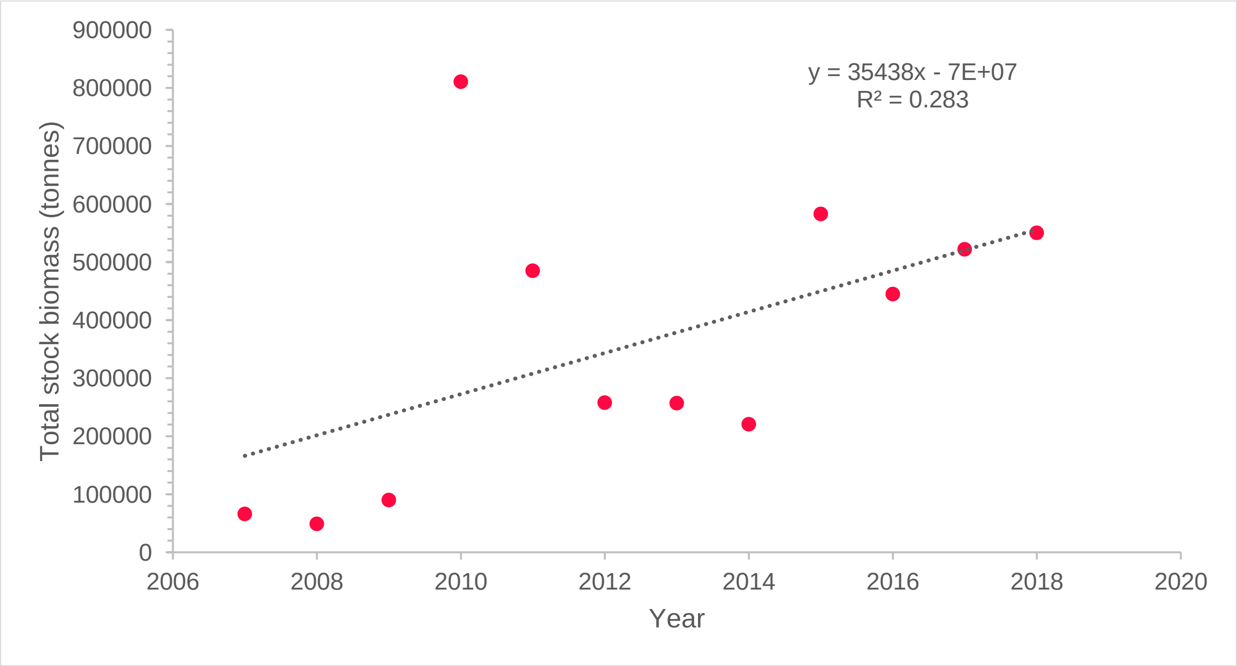


Plate 4-5: Abundance (Total Stock Biomass in Tonnes) of Sandeels in ICES Area 4 (which Includes the No-Take Zone off East Scotland that was Established in 2000) in the Period 2007 to 2018. Data from ICES (2020).

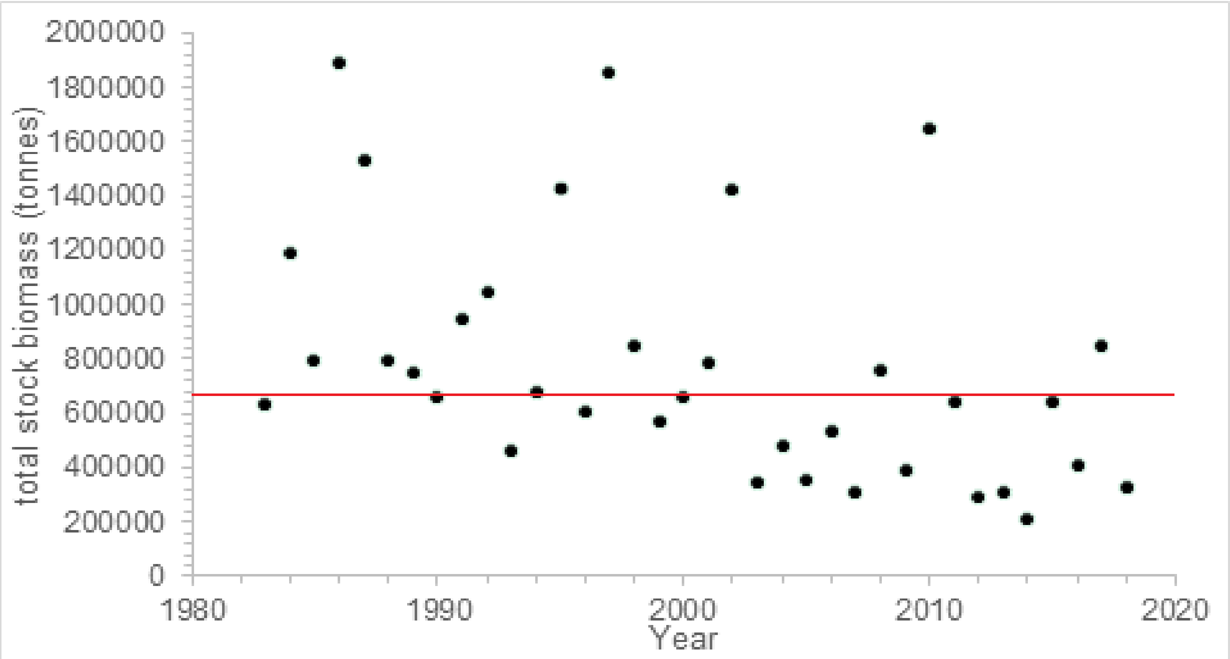


119. The productivity of kittiwakes at FFC SPA is significantly correlated with sandeel stock biomass. The relationship found by Carroll et al. (2017) for kittiwakes at FFC SPA in relation to sandeel stock in International Council for the Exploration of the Sea (ICES) North Sea sandeel management Area 1r ('Dogger Bank' and neighbouring areas) is similar to that previously identified elsewhere: kittiwake breeding success and adult survival at Shetland was closely related to changes in sandeel stock biomass in that area (Furness and Tasker 2000, Oro and Furness 2002, Furness 2007), and kittiwake breeding success at the Isle of May was strongly influenced by effects of sea surface temperature and sandeel fishing on the sandeel stock off the Firth of Forth, east Scotland (Frederiksen et al. 2004).

120. Lindegren et al. (2018) carried out a hindcast analysis of the Dogger Bank sandeel stock to assess the consequence of the high fishing mortality. They estimated that sandeel spawning stock biomass would have been about twice as large now as it is, if the fishery had maintained fishing mortality (F) at F=0.4 rather than at the levels of F=0.8 to 1.2 as seen during 1999-2009 in the history of this fishery. Indeed, the stock would be even larger now if there had been no fishery harvesting sandeels, although Lindegren et al. (2018) did not report on that scenario. However, their results further support the conclusion that the high fishing mortality imposed on the sandeel stock has been a major influence on the abundance of the sandeel, and hence on the breeding success of kittiwakes. Lindegren et al. (2018) also identified influences of sea temperature and copepod abundance on the abundance of sandeels, and suggested that long term trends in those drivers may inhibit recovery of sandeels if fishing pressure was reduced. In addition, severe reduction in forage fish stock biomass can lead to increased natural mortality that may inhibit recovery, and there is evidence of this with sandeel declines to low biomass (Saraux et al. 2020). At present, the Dogger Bank sandeel stock remains considerably below its long term average abundance, and is subject to a fishing mortality around F=0.6 (ICES 2020), a figure above the level tested in the scenario of Lindegren et al. (2018), and a figure which their scenario modelling clearly demonstrates has a negative impact on sandeel abundance. Indeed, at present the spawning stock biomass in this area is less than 10% of its highest historical level and is slightly below the limiting spawning stock biomass at which ICES should recommend closure of the fishery (Blim of 110,000 tonnes SSB) because there is an increased risk of recruitment failure in this stock (ICES 2020).

121. Cury et al. (2011) used empirical evidence from several seabird-fishery interactions around the world to suggest that management should aim to keep food fish stocks such as sandeels above a threshold of one-third of their historical maximum biomass in order to achieve good productivity among dependent seabird populations. The southern North Sea sandeel stock has fallen far below that rule of thumb management objective. Maximum total stock biomass in ICES area 1r was just below 2,000,000 tonnes during the 1980s at a time of high fishing effort, so likely to be reduced relative to unfished biomass (Lindegren et al. 2018). Nevertheless, if we take 2,000,000 tonnes as maximum biomass for this stock, then the Cury et al. (2011) threshold to avoid impacts on dependent predators such as kittiwakes would be a fished total stock biomass of 666,667 tonnes. Using this rule of thumb, the sandeel fishery has been harvesting from a stock biomass that was below this threshold abundance in 13 of the 16 years 2003-2018 (ICES 2020). The long-term deterioration of this heavily fished stock and its tendency to be below the Cury et al. (2011) threshold in recent years is clear in **Plate 4-6**.

Plate 4-6: Total Stock Biomass (Tonnes) of Sandeels in ICES Area 1r (Dogger Bank Stock) from 1983 to 2018 (ICES 2020), in Relation to the Cury et al. (2011) 'Rule of Thumb' that Stock Biomass should be Maintained Above One-Third of the Historical Maximum (in this case above 666,667 Tonnes, as Indicated by the Horizontal Red Line) to Avoid Adverse Impacts on Dependent Seabird Populations



122. This suggests that the continuation of sandeel fishery is likely to continue to cause mortality of many thousands of kittiwake chicks per year compared to a scenario with no fishing of the sandeel stock. It also identifies that the single most effective practical management action to assist the kittiwake population would be closure of the sandeel fishery (Carroll et al. 2017, Lindegren et al. 2018, Wright et al. 2018). Mortality of chicks has less impact on the kittiwake population than the same mortality of adults. On the basis of the demographic parameters of kittiwakes in the North Sea (adult survival 0.854, juvenile survival 0.79, age of first breeding 4 years; Horswill and Robinson 2015), two fledglings would be required, on average, to give rise to one adult surviving to recruit into a local colony at 4 years of age (i.e. 0.79 x 3 = 0.49). If sandeel fishing reduced productivity at FFC SPA by an average of 0.5 chicks per pair per year which appears to be approximately the scale of the impact indicated by the data for this region and equals the estimate for the kittiwakes at the Isle of May, that would be equivalent to 50,000 pairs x 0.5 chicks per pair, or 25,000 chicks that die due to scarcity of sandeels. If those chicks had survived to fledge, they would result in about 12,000 adults per year surviving to recruit into colonies at 4 years of age. That is three to four times more than losses estimated to be caused by collision mortality at offshore wind farms in UK North Sea, so represents a potential for far greater compensation than the precautionary estimate of losses incurred due to all installed, consented, and submitted proposals for UK offshore wind projects.

123. In view of the large numbers of kittiwake chicks dying at FFC SPA as a consequence of reduced abundance of sandeels due to fishing impacts, there is evidently scope for compensation through either reducing fishing effort directed at sandeels, or through closing areas within the main foraging range of this kittiwake population to sandeel fishing. ICES promotes ‘ecosystem-based management’ of fish stocks. However, their management of the sandeel stock has recently been criticised as not being ‘ecosystem-based’ because it sets a quota only on the basis of sustaining the sandeel stock and not on the basis of the needs of higher trophic level predators such as kittiwakes (Hill et al. 2019). ICES should therefore be highly receptive to the need to better manage that sandeel stock to avoid adverse impacts on kittiwakes and other top predators.

124. An extension to a proposed fisheries management area or a new proposal would need to be facilitated by the UK Government in allocating appropriate powers to a relevant management body and, potentially, through the delivery of legislation to secure the necessary powers.

4.5.2 Habitat Management Plan to Establish No-Take Zones for Sprat

125. During summer, sprats tend to be in shallow marine habitats influenced by freshwater inflows into the sea. Their distribution in the North Sea is predominantly southern, mainly south and east of the Dogger Bank, but spreads over much larger areas when the sprat stock increases in biomass, and then extends as far as Shetland, with concentrations in the Moray Firth, Tay, and Firth of Forth (Heessen et al. 2015, ICES 2020). Similarly, sprat catches tend to focus on the highest sprat density areas in the southern North Sea, but catches are taken as far north as Shetland in years of high stock biomass, as in 2019 (ICES 2020). Diets of breeding kittiwakes are not well known for many colonies, but at most sites where these have been studied there has been an overwhelming dominance of sandeel in kittiwake breeding season diet. Exceptions to this include small colonies of kittiwakes in the upper Firth of Forth and at Lowestoft, where sprats are believed to represent a significant part of breeding kittiwake diet and to support high breeding success at those colonies (Lothian Ringing Group, pers. comm., Mike Swindells, pers. comm.). It is therefore likely that kittiwakes at such colonies would benefit from a sprat no-take zone being established since that would be expected to lead to an increase in sprat stock biomass. It is not known whether kittiwakes at FFC SPA consume sprats while breeding, but this may not be the case, so that compensation through limiting depletion of sprat abundance may not have any significant effect on breeding success of kittiwakes at FFC SPA. That makes this potential compensation measure likely to be a low priority for this particular case, although it might be expected to benefit the kittiwake meta-population of which FFC SPA is part, through increasing food availability for kittiwakes in locations such as Lowestoft.

4.5.3 Construction of New Artificial Breeding Sites for Kittiwakes at Sea

126. Christensen-Dalsgaard et al. (2019) describe breeding by kittiwakes on six offshore oil platforms in Norwegian waters (five in the Norwegian Sea and one in the Barents Sea). The largest of these colonies was 674 nests on the oil platform Draugen, operated by OKEA, 75 km offshore. There were also 252 nests on Heidrun platform, operated by Equinor, 165 km offshore. Overall, they found over 1,200 pairs of kittiwakes nesting on these oil rigs in 2019 (exact numbers were not counted on two rigs so are not included in the total), and breeding success on the oil rigs was significantly higher than at coastal artificial colonies in the same part of the Norwegian coast (they list for comparison colony sizes and breeding success achieved at four artificial colonies on the Norwegian coast at fishing ports), and on average about four times higher than at natural colonies in the same part of Norway (they list for comparison colony sizes and breeding success at four neighbouring natural colonies). They suggest that the higher breeding success on oil rigs is likely to be due to higher food availability (the birds nesting offshore being at foraging grounds so not having to commute as far as birds that nest at the coast) and also to fewer predators at the oil rigs. They point out that predation on kittiwake nests on the oil rigs may not by zero. In particular, "kittiwakes breeding on the exposed parts of the rigs, had a lower productivity than those breeding on more sheltered parts of the rig". Christensen-Dalsgaard et al. (2019) suggest that this may be due to predation by large gulls, which are able to access nests that are in open areas, but cannot access nests that are sheltered. However, the difference could potentially relate to exposure to rain and direct sunshine, which can also cause breeding failure of exposed nests. While artificial nest sites offshore in the southern North Sea may provide similar advantages in terms of proximity to kittiwake feeding grounds and protection from disturbance and predators, at sea artificial colonies would be more expensive to construct, may increase collision risk if located near to offshore wind farms, and would be much more difficult and expensive to monitor to demonstrate effective compensation. For these reasons, this approach may be low priority in terms of suitability for compensation.

4.5.4 Construction of New Artificial Breeding Sites for Kittiwakes on the Coast

127. This concept has been reviewed in detail by Ørsted (2020a,b,c,d,e,f). Kittiwakes readily use artificial nest sites where natural sites are not available or are in limited supply. These include harbour walls, buildings as diverse as warehouses, stone bridges, metal bridges, castles, churches, oil and gas platforms, power station water pipes, and purpose-made artificial colony sites to replace buildings being demolished. Breeding success on artificial structures can be at least as high as in natural colonies, and can be higher where artificial sites are distant from any large kittiwake colonies, close to food supplies and safe from predators (Christensen-Dalsgaard et al. 2019). In the Norwegian context, Christensen-Dalsgaard et al. (2019) conclude "the increasing numbers of kittiwakes breeding on man-made structures both offshore and on the coast clearly provide a significant contribution of juveniles to the impoverished kittiwake population in Norwegian waters".

128. Hornsea Three has proposed constructing four new artificial colonies for kittiwakes at two sites in the vicinity of Lowestoft to Sizewell, and two sites in the vicinity of the Tees Estuary to south of Seaham. Their plan (Ørsted 2020b) states "The design specifications for the artificial nesting structures are at this stage unconstrained. They may take the form of a bespoke structure or be a modification to an existing building or piece of infrastructure (such as a seawall). Where two structures are located in the same search zone, the intent is that they are different designs to maximise the opportunity for kittiwake to colonise. The structure designs will likely be influenced by landowner negotiations, landscape character, and existing environment of the selected location." Similar structures, in the same part of England, have been proposed as compensation, if required, by Norfolk Vanguard and Norfolk Boreas (Royal Haskoning DHV 2020). This leads to a potential difficulty of competition among developers to construct artificial nesting colonies for kittiwakes at multiple sites on the east coast of England. For this reason, we suggest that this may not be the best approach to take if the proposals relating to Hornsea Three, Vanguard and Boreas do proceed. Furthermore, there is evidence that some artificial structures are not accepted by kittiwakes or do not allow successful breeding, and therefore there is uncertainty that provision of new artificial structures will achieve the output of fledglings required to compensate for losses due to collision mortality. To provide successful compensation, new artificial colonies need to be adopted by kittiwakes and to result in high breeding success. Pairs breeding at those sites need to produce about 0.8 chicks per nest just to maintain the population at the new artificial site. So only breeding success in excess of 0.8 chicks per nest will represent potential compensation for losses of birds through collision mortality. Artificial sites therefore need not only to be used, but need to achieve higher breeding success than at natural colonies of kittiwakes so that the surplus production provides compensation.

4.5.5 Adjustment of Existing Artificial Nest Sites to Enhance Breeding Success of Kittiwakes

129. Surveillance of breeding success of kittiwakes on artificial structures has shown typically very high breeding success at Lowestoft and at the Tyne. However, not all areas used at Lowestoft have shown high breeding success in all years. In particular, the artificial ledge constructed at Lowestoft harbour may be exposed to predation by gulls and even by foxes. Careful alterations could greatly improve breeding success of pairs that are currently exposed to gulls, exposed to weather (rain and direct sunshine) and to foxes. Similarly, at the Tyne, kittiwakes have nested in 28 discrete locations that have been monitored annually by local ornithologists (Turner 2010, and annual reports). One of the two structures constructed specifically for kittiwakes to nest on has never been used (and has now been removed because it has been unsuccessful). While breeding success has been consistently high overall for the sum of all the Tyne artificial sites, it has been consistently higher on some structures than on others. For example, breeding success has generally been higher on Tyne Bridge abutments than on Tyne Bridge girders, but has been higher on the Tyne Bridge than on Saltmeadows Tower (the more successful of the two structures built for the kittiwakes, but apparently not allowing as high breeding success for some reason as can be achieved on some of the other structures in the same area). Identification of the features of nest sites that are successful and nest sites that are unsuccessful would permit adjustments of existing structures to make more of the nest sites able to support successful breeding by kittiwakes. Since this approach has not been suggested by any other offshore wind farm developers as a form of compensation, yet has the potential to increase productivity substantially, this should be a high priority. It would also be complementary to the construction of novel colony sites proposed by Hornsea Three, Vanguard and Boreas. This approach could boost breeding success of pairs attempting to nest on sub-optimal artificial nest sites. For example, nest sites where breeding success is zero could potentially be improved to the typical levels of around 1.1 to 1.3 chicks per nest achieved at many nests on artificial structures where the nest is protected from predators and weather. Boosting breeding success by around 1 chick per nest by making nests predator and weather resistant would provide appropriate compensation for relatively small levels of estimated collision mortality, so this may be the most appropriate method in the case of proposed extensions to Dudgeon or Sheringham offshore wind farms.

4.6 Proposed Approach to Delivery of Compensation

4.6.1 Next Steps

130. The short-listed compensatory measures are summarised in **Table 4-4**.

Table 4-4: Summary Traffic Light Assessment of Five Short-Listed Compensatory Measures

Measure	Evidence supporting effectiveness	Feasibility as a strategic measure	Feasibility as a developer-led local measure	Likely further scope for this after Hornsea, Vanguard, Boreas and others	Cost-effectiveness
Habitat management plans to establish no-take zones for sandeel	High	High	Low	High	High
Habitat management plans to establish no-take zones for sprat	Low	High	Low	Low	Low
Construction of new artificial breeding sites for kittiwakes at sea	High	High	Moderate	High	Low
Construction of new artificial breeding sites for kittiwakes on the coast	High	Moderate	High	Low	High
Adjustment of existing artificial nest sites to enhance breeding success of kittiwakes	High	Low	High	High	High

131. Two of the possible compensatory measures appear most practical and highly effective: Habitat management plans to establish no-take zones for sandeel, and adjustment of existing artificial nest sites to enhance breeding success of kittiwakes.

4.6.1.1 Habitat Management Plans to Establish No-Take Zones for Sandeel

132. There is some evidence to suggest that recovery of sandeel stocks may be slow, or incomplete, as a consequence of other ecological factors (for example the effects of climate change on zooplankton on which sandeels feed, such as large copepods, and the recovery to high abundance of predatory fish such as cod, hake, haddock and whiting that eat sandeels) and impacts of climate change (Lindegren et al. 2018). Therefore, any compensation (in terms of improved stock biomass) on these grounds should aim to exceed the minimum suggested by the statistical relationship between sandeel total stock biomass and kittiwake productivity. As noted above, at present no authority has the jurisdiction to deliver fisheries management areas as compensation. An extension to a proposed fisheries management area or a new proposal would need to be facilitated by the UK Government in allocating appropriate rights to a relevant management body and, potentially, through the delivery of legislation to secure the necessary rights. The feasibility of this measure therefore depends on the UK Government taking this on board as strategic compensation for the industry. This measure therefore has a strong evidence base to indicate high confidence in being successful in providing compensation, but requires a strategic approach by UK Government. We strongly advocate a collaborative process between SNCBs, developers and NGOs to encourage UK Government to take this approach forward on behalf of the industry and UK society.

4.6.1.2 Adjustment of Existing Artificial Nest Sites to Enhance Breeding Success of Kittiwakes

133. There is a need to review the breeding success achieved by kittiwakes on different artificial structures at the River Tyne and Lowestoft, and to assess the features of individual nest sites on those structures that determine breeding success. That would then allow adjustments to be made to enhance breeding success where that is practical. For example, it is highly likely that providing a small overhang above the nesting ledge on Lowestoft harbour would make the nests on that ledge inaccessible to large gulls and crows that are predators of eggs and chicks there at present, as well as making the nests less likely to be damaged by heavy rain.

4.6.2 Monitoring

134. Habitat management plans to establish no-take zones for sandeel:

- The breeding success of kittiwakes at FFC SPA is already monitored, so the consequence of adjusting sandeel fishing effort would be visible from the long-term data on kittiwake breeding success. Breeding success is also already monitored at other colonies that are distant from the southern North Sea sandeel stock and the productivity of those colonies would provide some baseline data against which to compare FFC SPA productivity. However, there would be no ideal ‘control’ for this manipulation. Similarly, sandeel stock biomass is assessed annually by ICES. There is no ‘control’ site in that case either, but population modelling (Lindegren et al. 2018) provides strong evidence of the changes resulting from adjustment of fishing effort. By such mechanisms it would therefore be possible to monitor the effectiveness of this compensation.

135. Adjustment of existing artificial nest sites to enhance breeding success of kittiwakes:

- Monitoring the effectiveness of adjustments to nest site quality is straightforward. This can be done by making three visits to the site, one in mid-late May to photograph the colony, and label all nests on reference photographs, one in the second half of June to identify which nests have failed early, and a third in mid-July to count the number of chicks in each nest. This will allow the breeding success of adjusted nest sites to be recorded in a Before-After-Control-Impact (BACI) design (nests that have not been adjusted provide the Control sample). This methodology will quantify the gain made by adjusting nest sites to increase breeding success, so will give a reliable measure of the effectiveness of compensation.

4.6.3 DCO Condition

136. [Subject to preferred measure]

4.7 FFC SPA Summary

137. The ideal approach would be a strategic one led by UK Government to provide compensation on behalf of industry and UK society by establishing sandeel no-take zones that will allow sandeel stock biomass to recover from the present heavily fished condition towards a higher unfished abundance level. That would allow significant increase in kittiwake breeding success that would more than compensate for in-combination impact of offshore wind developments on kittiwakes. A second possibility would be compensation provided by DEP and SEP by adjusting existing artificial nest sites (for example at River Tyne and Lowestoft) to enhance breeding success of kittiwakes attempting to nest on artificial structures in sub-optimal nest sites where they currently achieve lower breeding success than they could if those nest sites were better protected from predators and weather. The latter approach is one that as far as we know has not yet been proposed by any other offshore wind farm developers, but would be effective and practical, at least to provide the relatively small level of compensation required for an individual wind farm development. This would also be complementary to the proposal to create novel artificial colonies as put forward by Hornsea Three, Norfolk Vanguard and Norfolk Boreas.

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