Hornsea Project Four: Derogation Information

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Volume B2, Annex 7.3: Compensation measures for FFC SPA: Onshore Artificial Nesting: Ecological Evidence

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Glossary

Term	Definition
Commitment	A term used interchangeably with mitigation and enhancement measures. The purpose of Commitments is to reduce and/or eliminate Likely Significant Effects (LSEs), in EIA terms. Primary (Design) or Tertiary (Inherent) are both embedded within the assessment at the relevant point in the EIA (e.g. at Scoping, Preliminary Environmental Information Report (PEIR) or ES). Secondary commitments are incorporated to reduce LSE to environmentally acceptable levels following initial assessment i.e. so that residual effects are acceptable.
Cumulative effects	The combined effect of Hornsea Four in combination with the effects from a number of different projects, on the same single receptor/resource. Cumulative impacts are those that result from changes caused by other past, present, or reasonably foreseeable actions together with Hornsea Project Four.
Design Envelope	A description of the range of possible elements that make up the Hornsea Project Four design options under consideration, as set out in detail in the project description. This envelope is used to define Hornsea Project Four for Environmental Impact Assessment (EIA) purposes when the exact engineering parameters are not yet known. This is also often referred to as the "Rochdale Envelope" approach.
Development Consent Order (DCO)	An order made under the Planning Act 2008 granting development consent for one or more Nationally Significant Infrastructure Projects (NSIP).
Environmental Impact Assessment (EIA)	A statutory process by which certain planned projects must be assessed before a formal decision to proceed can be made. It involves the collection and consideration of environmental information, which fulfils the assessment requirements of the EIA Directive and EIA Regulations, including the publication of an Environmental Impact Assessment (EIA) Report.
Hornsea Project Four Offshore Wind Farm	The term covers all elements of the project (i.e. both the offshore and onshore). Hornsea Four infrastructure will include offshore generating stations (wind turbines), electrical export cables to landfall, and connection to the electricity transmission network. Hereafter referred to as Hornsea Four.
Landfall	The generic term applied to the entire landfall area between Mean Low Water Spring (MLWS) tide and the Transition Joint Bay (TJB) inclusive of all construction works, including the offshore and onshore ECC, intertidal working area and landfall compound. Where the offshore cables come ashore east of Fraisthorpe.
Maximum Design Scenario (MDS)	The maximum design parameters of each Hornsea Four asset (both on and offshore) considered to be a worst case for any given assessment.
Mitigation	A term used interchangeably with Commitment(s) by Hornsea Four. Mitigation measures (Commitments) are embedded within the assessment at the relevant point in the EIA (e.g. at Scoping, or PEIR or ES).
National Grid Electricity Transmission (NGET) substation	The grid connection location for Hornsea Four.
Onshore export cables	Cables connecting the landfall first to the onshore substation and then on to the NGET substation at Creyke Beck.

Onshore substation (OnSS)	Comprises a compound containing the electrical components for transforming the power supplied from Hornsea Project Four to 400 kV and to adjust the power quality and power factor, as required to meet the UK Grid Code for supply to the National Grid. If a HVDC system is used the OnSS will also house equipment to convert the power from HVDC to HVAC.
Order Limits	The limits within which Hornsea Project Four (the 'authorised project) may be carried out.
Orsted Hornsea Project Four Ltd.	The Applicant for the proposed Hornsea Project Four Offshore Wind Farm Development Consent Order (DCO).
Planning Inspectorate (PINS)	The agency responsible for operating the planning process for Nationally Significant Infrastructure Projects (NSIPs).
Trenchless Techniques	Also referred to as trenchless crossing techniques or trenchless methods. These techniques include Hydraulic Directional Drilling (HDD), thrust boring, auger boring, and pipe ramming, which allow ducts to be installed under an obstruction without breaking open the ground and digging a trench.

Acronyms

Term	Definition
DCO	Development Consent Order
ECC	Export Cable Corridor
EIA	Environmental Impact Assessment
ES	Environmental Statement
HRA	Habitats Regulations Assessment
HVAC	High Voltage Alternating Current
HVDC	High Voltage Direct Current
MDS	Maximum Design Scenario
MLWS	Mean Low Water Springs
MPA	Marine Protected Area
PEIR	Preliminary Environmental Information Report
PINS	The Planning Inspectorate
SPA	Special Protection Area

1 Introduction

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

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

2 Kittiwake

2.1 Overview

2.1.1.1 Providing additional nesting opportunities for kittiwakes could potentially enhance productivity and therefore be effective as a compensatory measure. Kittiwakes are known to nest successfully on man-made structures and have readily adapted to artificial nesting structures in onshore and offshore environments. The merits of this compensatory measure have been discussed in detail for Hornsea Project Three within Orsted's '**Response to the Secretary of State's Minded to Approve Letter Annex 2 to Appendix B (Kittiwake Compensation Plan): Kittiwake Artificial Nest Provisioning: Ecological Evidence report' (Sept 2020)**.

2.1.1.2 The key findings of this report was broadly supported by SNCBs as an adequate compensatory measure for Hornsea Project Three. A Development Consent Order for Hornsea Three was received from the Secretary of State on 31 December 2020 with this compensation measure included as a condition.

2.1.1.3 The current main drivers of kittiwake populations are food abundance, fisheries (depletion of stock, reduction in discards) and climate change. This report considers a management option based on the provision of artificial nest sites so as to increase the annual recruitment of kittiwake into the wider North Sea. This is considered feasible as evidenced by the colonisation of man-made structures in open seas, coastal sites, and urban areas, and in significant numbers. In doing so, the intention would be to compensate for the annual loss of the predicted mortality of kittiwakes from Flamborough & Filey Coast SPA (FFC SPA) due to collisions with turbines at Hornsea Four.

2.1.1.4 This report presents an updated account of the evidence base on the potential for artificial nest sites to increase the annual recruitment of kittiwake into the regional population of the southern North Sea, which forms part of the wider Eastern Atlantic population. Suitable coastal locations and sea areas are defined in the southern North Sea for installation of or modification to existing / in plan structures to provide artificial nesting structures for kittiwakes. An outline plan of its design and delivery is provided, with the focus on delivery of compensation for the Adverse Effect on Site Integrity at the FFC SPA.

2.2 Methods

2.2.1 Literature Review

2.2.1.1 Coulson's (2011) monograph on the kittiwake provides a comprehensive review of biology and research on the species up to the year of its publication. In order to update the state of current knowledge on kittiwake biology to inform this report, a literature search was performed for relevant research published since 2010. An image search and web search of grey literature was also undertaken to extract additional information and population trends from areas where kittiwakes have been documented nesting on man-made structures.

2.2.2 Data Search

2.2.2.1 Data on population and productivity trends of birds in the southern North Sea region were extracted from the JNCC's Seabird Monitoring Program (SMP) database (https://jncc.gov.uk/our-work/seabird-monitoring-programme/).

2.3 Propensity for kittiwake to colonise artificial nesting structures

2.3.1 Rationale

2.3.1.1 Providing additional nesting opportunities for kittiwakes could potentially enhance productivity and therefore be effective as a compensatory measure. Kittiwakes are known to nest successfully on man-made structures and have readily adapted to artificial nesting structures provided elsewhere. For this scheme to be effective, new birds must be available to colonise and breed successfully on structures provided. This section considers the evidence on kittiwake biology which indicates how likely birds are to colonise new nesting sites. It also identifies the factors which are likely to be important for the long-term establishment of a new colony (e.g. ecological requirements – proximity to food, lack of predation, low intraspecific competition, proximity to seed population). Finally, it highlights areas in the southern North Sea which could meet these requirements by recruiting kittiwake into the wider North Sea population.

2.3.2 Life History Characteristics

2.3.2.1 Kittiwakes are colonial seabirds which naturally breed on vertical rocky sea-cliffs (Coulson 2011). They are particularly well adapted to nest on narrow ledges making substantial nests from mud, grass and/or seaweed.

2.3.2.2 Birds breed in colonies with numbers ranging from a few pairs to a few thousand. Colonialism offers birds greater protection from predators and the presence of other kittiwakes is required for birds to reach breeding condition (Coulson 2011). Birds generally lay two eggs during the breeding season (March – July) (Coulson 2011). After fledging, young birds generally remain at sea for 2-3 years before attempting to recruit into the breeding population. Kittiwakes are long-lived birds with an average life expectancy of around 12 years (Robinson *et al.* 2005).

Conclusion	Context
Kittiwakes breed, on average, in their third or fourth year, rearing up to two (very occasionally three or four) chicks per year.	There would be a time-lag between when chicks fledged from a structure and the point where they could contribute to the impact in question

2.3.3 Colony Recruitment / Philopatry

2.3.3.1 Kittiwakes are not highly philopatric, meaning birds do not tend to return to their natal colony to breed (Coulson and Coulson 2008). Between 11-23% of birds are thought to return to the colony where they were raised (and those that do are mostly males) (Coulson 2011, Horswill and Robinson 2015). Birds seem to visit several colonies as juveniles before settling on a breeding site. First-time breeders tend to arrive at colonies later in the season and may attempt to pair up and breed, however, they are typically unsuccessful (Coulson 2011).

2.3.3.2 The mechanisms driving prospecting behaviour and settlement decisions in seabirds are unclear, but perhaps these attempts allow birds to gain information on the quality of the site before returning in subsequent years to join the breeding population (Boulinier *et al.* 1996). Birds have been recorded breeding up to 1,600 km away from their natal colony, however, the majority of birds usually choose sites within a neighbouring colony (<100 km) (Coulson 2011). For kittiwakes in the Atlantic, natal dispersal occurs more frequently at large colony sizes (McKnight *et al.* 2019). Juveniles may therefore be more likely to disperse to new sites from sizable UK colonies such as the FFC SPA.

Conclusion	Context
As few as 11% of kittiwakes breed in their natal colony, majority choose sites within a neighbouring colony (<100 km) so connectivity between UK breeding colonies is high	A structure on the east coast of England is likely to be colonised with birds from across other east coast colonies and beyond.

2.3.3.3 Once birds have successfully recruited into a breeding colony, they show high levels of site fidelity, often returning to the same nest year after year (Coulson, 2011). Thus, once established, locations of colonies tend to be retained over many decades.

2.3.3.4 However, site fidelity is ultimately dependent on individual and conspecific reproductive success (Boulinier *et al.* 2008; Danchin *et al.* 1998). A recent study using bird-borne telemetry devices showed that failed breeders may make prospecting movements to other colonies within the same breeding season, and that this behaviour becomes more prevalent if they nest within a colony experiencing widespread breeding failure (Ponchon *et al.* 2015; Ponchon *et al.* 2017). Successful breeders (and birds nesting at successful colonies) do not seem to make these prospecting trips. Individual and colony success impacts the likelihood of birds returning to a colony, failed breeders had a return rate of 45% compared to 75% for successful breeders (Ponchon *et al.* 2017). However, birds nesting in successful colonies are less likely to disperse after a failure. The chance of dispersal (at a local scale) also seems to be higher in low density colonies and for first time breeders (Acker 2017).

Conclusion	Context
Once a bird has established a site within a successful breeding colony, high site fidelity is shown. If repeated breeding failures occur, then birds are more likely to switch sites	If an artificial structure is successful, birds are likely to return to breed for the duration of their lifespan (avg. 12 years)

2.3.3.5 Immigration is an important regulator of colony population dynamics in kittiwakes, so, the availability of recruits from nearby colonies will be an important consideration in determining the location of potential new nesting sites. It is unlikely that placing an artificial nesting site near another colony would diminish the population of established breeders, providing the colony was not in decline.

Conclusion	Context
Colonisation of new sites is largely driven by immigration, once birds have established a nesting site (providing conditions are good) they are unlikely to relocate.	It is unlikely that placing an artificial nesting site in close proximity to another colony would diminish the population of established breeders, providing the colony was not in decline.

2.3.4 Diet and foraging behaviour

2.3.4.1 Seabirds are central-place foragers, constrained to a restricted range of feeding sites within reach of their colony during the breeding season. On average, kittiwakes forage within 54.7(±50.4) km of their breeding colony but can travel up to 156.1 (±144.5) km to find food. The maximum foraging range for the species is currently 770 km (Woodward *et al.* 2019), however, shorter foraging trips are generally linked to higher breeding success (e.g. Daunt *et al.* 2002, Lewis *et al.* 2001).

2.3.4.2 Seabird colony size and location are strongly influenced by prey availability (Frederiksen *et al.* 2005, Jovani *et al.* 2015). Kittiwake diet consists mainly of marine fish and invertebrates obtained offshore, but they also take discards from fishing activities

(Coulson 2011). Birds generally feed in flocks and can only access prey in the top metre of the water column. This surface feeding strategy is high risk and leaves the birds vulnerable to changes in prey distribution.

2.3.4.3 Kittiwake show a well-defined seasonal change from foraging on planktonic crustacea in early spring, to 1+ group sandeels in April and May, to 0 group sandeels in June and July (Lewis *et al.* 2001). During the rearing of chicks, birds require small fish of a young age class. Other than size, birds do not seem to be too selective of the prey they catch, taking what is available in the local area (Coulson 2011). Diets can differ between UK colonies but sandeels appear to be dominant in the majority of locations (Chivers *et al.* 2012, Bull *et al.* 2004, Furness and Tasker 2000). In two colonies in Ireland, regurgitates from kittiwakes during the early chick-rearing period showed Clupeids to be the dominant food source at both colonies (Chivers *et al.* 2012).

2.3.4.4 Around the UK coast, sandeels are a particularly important energy-rich prey species during the breeding season, with sprats and young herring key alternative prey species. Sandeel have a restricted and patchy distribution due to their particular habitat requirements (Wright *et al.* 2000, Holland *et al.* 2005). Kittiwake reproductive performance is strongly linked to local sandeel availability (Harris and Wanless 1997, Cury *et al.* 2011, Cook *et al.* 2014). As such, seabirds nesting at specific colonies are heavily reliant on regional sandeel aggregations (Frederiksen *et al.* 2005).

2.3.4.5 There has been a reduction in the prevalence of sandeel in the diets of North Sea seabirds in recent decades (Wanless *et al.* 2018). Kittiwakes have experienced the largest population declines in recent years in areas where birds are heavily reliant on sandeel with no alternative prey available i.e. northern regions of the North Sea. In the southern North Sea, where juvenile herring and sprats are abundant population declines have been less pronounced (Frederiksen *et al.* 2005, Daan *et al.* 1990), however, sandeel still makes up a major (60%) component of seabird diet during the breeding season in this region (Furness and Tasker 2000).

2.3.4.6 Sandeel are subject to fishing pressures in UK waters (ICES 2018), and these have been linked to declines in kittiwake breeding success (Cook *et al.* 2014, Carroll *et al.* 2017). There is some evidence that climatic changes such as increases in sea surface temperatures may be decreasing the nutritional quality of sandeel and may cause a northward range shift in the future (Frederiksen *et al.* 2012 but see Eerkes-Medrano *et al.* 2016). Therefore, proximity to multiple foraging opportunities is a key consideration to ensure resilience of a population to local food shortages (e.g. see Peredes *et al.* 2012). This topic is also covered in depth in the Supporting Evidence for Kittiwake Prey Resource report prepared by Hornsea Three in response to the Secretary of State's Minded to Approve Letter (**Appendix C to the Applicant's Response**).

2.3.4.7 Alongside nesting habitat and prey availability, kittiwake distributions may be modulated by density dependent competition between individuals nesting at other colonies nearby (e.g. Wakefield *et al.* 2013). Kittiwakes can display high foraging-site fidelity (Irons 1998, Harris *et al.* 2020). Recent tracking studies show birds tend to avoid foraging in areas that are populated with a higher number of birds from a neighbouring colony than from their own colony (Wakefield *et al.* 2017). There is also some evidence to suggest that these patterns may also operate on smaller scales i.e. at a sub colony level (e.g. within RSPB FAME tracking data). This may be an important factor to consider when choosing an area in which to enhance kittiwake populations, as increased competition for the same food resources could potentially impact the breeding success (and therefore population numbers) of birds in both the 'new' or established colonies. However, density dependent processes are secondary to food availability and there appears to be no negative relationship between colony size and breeding success in kittiwakes (Frederiksen *et al.* 2005).

Conclusion	Context
Kittiwake require small forage fish to feed their chicks. Group 0 sandeel seem to be the most important, but birds can be successful if there are key alternatives if these become unavailable. Birds may have higher foraging (and subsequent breeding) success at lower levels of density dependent competition.	The location of a structure would need to be within the foraging range of kittiwakes (<156 km) to these resources. Structures may have a higher chance of success at increasing distances from very large colonies e.g. FFC SPA population.

2.3.5 Use of artificial /man-made structures for nesting

2.3.5.1 Kittiwakes do not seem to show a preference between natural or artificial nesting sites (Coulson 2011). Man-made structures such as buildings and piers meet similar nesting requirements to cliffs (i.e. vertical faces with narrow ledges, close to the water's edge) and have readily been adopted by kittiwakes in areas where natural breeding sites are in short supply. **Table 2.1** details known artificial nesting sites for kittiwakes in the north Atlantic (photographs of the type of nesting sites used can be found in **Appendix A**). Key features of these 'urban' kittiwake sites in the UK appear to be linked with old industrial fishing ports and harbours or aging seaside fishing towns with disused piers and buildings. However, once birds have established within a town setting, they also appear to favour ornate buildings like churches and town halls. Kittiwakes are known to feed on fishery discards (Coulson 2011) and birds may have initially been attracted to ports and harbours by following fishing vessels.

2.3.5.2 Offshore platforms such as those used for oil/gas exploration or other metal structures where ledges exist also appear attractive as prospective breeding sites (see **Table 2.1**). These sites may provide an additional benefit as they may be closer to potential foraging sites. Recent studies on birds nesting on offshore platforms off the Norwegian coast suggest breeding success may be higher at these locations than at natural sites (see examples within McArthur Green 2020).

2.3.5.3 Breeding success and survival rates of birds nesting in these urban sites are comparable (if not better) to those nesting at natural sites, most likely due to a lower risk of predation and less disturbance from other species (Turner 2010, Coulson 2011, McArthur Green 2020). Numbers appear to be increasing and productivity trends appear to be good at urban kittiwake sites in the UK, namely the Tyne colonies and at Lowestoft (see **Table 2.4, Table 2.5** and **Table 2.6**).

2.3.5.4 Numbers are also increasing at the urban site of Boulogne sur Mer on the French Coast (McMurdo-Hamilton 2016), and populations which have colonised offshore structures in the southern North Sea i.e. kittiwake at Sizewell Rigs also appear to be thriving with numbers having increased from 200 pairs in 2001 to 502 apparently occupied nests (AON) in 2008; the latter population is space-limited and unlikely to exceed 500 pairs (McMurdo-Hamilton 2016). Tracking devices deployed on birds nesting at the Tyne colony (which is the furthest inland (17 km) breeding kittiwake colony in the world) indicate urban birds seem to be using similar marine foraging areas to natural colonies on the north-east coast (Redfern and Bevan 2014).

2.3.5.5 Urban colonisation began in the UK as the kittiwake population was increasing, first occurring in 1931 with a pair nesting on Edinburgh pier (Coulson 2011). Since then, sites which have been colonised seem to be associated with areas where natural nest sites are becoming limited. In the north-east of England, it has been argued that the colonisation of buildings on the Tyne estuary occurred during a period where breeding numbers in the region more than doubled, indicating there were no shortages of natural nest sites in the region (Turner 2010). However, on the Tyne river, colonisation of buildings coincided with a time when many birds began to lose natural nest sites due to coastal erosion at Marsden cliffs (Coulson 2011). Kittiwakes on the Tyne now appear to be limited by the availability of suitable nesting sites (Turner 2010) and birds have begun to move further into the town centre resulting in some unusual nesting locations including the top of lampposts (see photos in **Appendix A**).

2.3.5.6 Once an urban nesting site has been established birds show a persistent ability to colonise structures, despite the presence of bird nesting deterrents (causing much frustration for town planners!). In the UK, France and in some Norwegian towns, attempts have been made to move birds from man-made nesting structures (due to health and safety issues, or if buildings are to be demolished or repurposed). Various artificial nesting structures have been designed to dissuade birds from nesting on buildings, or as compensatory measures during building/demolition works (see **Table 2.2**). The success of these projects has been mixed (**Table 2.2** and **Table 2.3**).

2.3.5.7 It is important to note that these situations involve(d) trying to move established breeding birds rather than attract new recruits. Birds show strong nest site fidelity once they have established territories, meaning most will try to return to an area as close to their original site as possible. For example, in Newcastle, 85% of kittiwakes evicted from the Baltic Flour Mill ended up nesting on other buildings along the riverside rather than on a compensatory artificial tower provided near their original nesting site. The artificial tower did successfully attract nesting birds, but these arrived later in breeding season (suggesting they were younger birds), so were most likely first-time breeders (Coulson 2011). The tower colony grew to support around 100 pairs per year, but due to health and safety issues regarding droppings, it was relocated to a less public site 2 km downstream (Coulson 2011). The tower continues to be used by birds to date, but productivity appears to be lower than birds nesting further along the Tyne, possibly due to issues with crow predation at the new site (D. Turner, pers comm.). Another tower of a similar design was built on the Tyne at South Shields in 2014. However, birds did not colonise this structure and it has since been removed (D. Turner, pers comm.).

Conclusion	Context
Kittiwakes show no preference for purpose-built artificial vs man-made structures. New recruits take to artificial sites faster than established breeders.	If designed correctly, in the right location, an artificial structure should have every chance of success in supporting a colony.

2.4 Potential southern North Sea locations for artificial nesting structures

2.5 North Sea population trends

2.5.1.1 In general, kittiwake populations across the UK have decreased over the past 20 years (SMP 2020). These population declines have been most pronounced in Scotland (Furness and Tasker 2000, Oro and Furness 2002, Furness 2007, Frederiksen *et al.* 2004), however, populations in the southern England have also declined, with a high proportion of colonies abandoned (McMurdo-Hamilton 2016). In contrast, there is evidence of colony expansion in the southern North Sea (McMurdo-Hamilton 2016) e.g. in Suffolk (Lowestoft and Sizewell), off the Dutch coast (colonisation of several oil and gas platforms), and Denmark (Bulbjerg in Thy).

2.5.1.2 Kittiwake population trends are primarily driven by productivity rates and to achieve a sustainable population, annual breeding success should be maintained at least 0.8 chicks per nest (Coulson 2017). It has been suggested that higher productivity rates are required to sustain kittiwake populations (Frederiksen *et al.* (2004): 1.17 chicks; Cook & Robinson (2010): 1.5 chicks), however, these values are higher than the average productivity rates reported at most colonies and productivity rates have been lower than this when population trends at some colonies were increasing (Coulson, 2017).

2.5.1.3 If populations in the surrounding area are decreasing (i.e. productivity trends are consistently lower than 0.8), this may be indicative of food shortages or other issues within the site that may make it unsuitable as a potential new colonisation site.

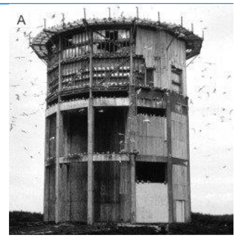
Table 2.1. Artificial nesting sites for kittiwakes.

Location	Site	Nesting habitat	Occupation and Population	Source
Alaska	Middleton Island	Abandoned military buildings and an island shipwreck	1950s – several thousand reported, population increased during the early 1980s but has subsequently declined to about 12,470 individuals in 2007.	Hatch *et al.* 1993.
Norway	Rost, Alesund, Lofoten island.	Sheds and houses in coastal towns	1950s-present in many sites around Norway	Wagner 1958
Norway	Grumant Island	Abandoned buildings	Currently nesting on the window ledges of abandoned buildings	Harris *et al.* 2019
Norway	Tromso	Buildings & artificial nesting platforms on buildings	2014/15-present. Currently 115 pairs (2019). Platform installed to discourage nesting on buildings 2019?	National Geographic online News.
Norway	Norwegian Sea/ Barents Sea	Offshore oil/gas platform	Currently nesting on several platforms	McArthur Green 2020
Norway	Utsira	Warehouses, wooden buildings	Current	Tveit *et al.* 2004.
Denmark	Hanstholm and Hirtshals	Breakwaters and buildings in the harbours	Current (80-100 pairs)	Lerche-Jørgensen *et al.* 2012.
The Netherlands	Texel	Offshore oil/gas platforms	2000-present? Nesting on many offshore platforms in the Frisian Front area (Southern North Sea)	Camphuysen & de Vreeze 2005, Camphuysen & Leopold 2007

Location	Site	Nesting habitat	Occupation and Population	Source
France	Boulogne-sur-Mer	Industrial buildings close to harbour. Also on an artificial wall and tower.	2000s-present. 891 breeding pairs in 2014	Pochon *et al.* 2017. (online: Flickr)
England	Tyneside	Factory buildings, town, and artificial nesting towers	1949-present. Population has spread from factories by fishing ports into Newcastle town centre. Artificial platforms provided in 1998 colonised in same year by a small number of birds.	Coulson 2011
England	Seaham, County Durham	Buildings within harbour	1960s-present	Coulson 2011
England	Bridlington, East Yorkshire	Buildings and harbour wall	1960s-present	Coulson 2011
England	Hartlepool, Cleveland	Warehouse buildings, fish quay, town, and pier	1960-present. First used warehouse buildings which were demolished, birds moved to fish quay and now nest on many industrial and residential buildings and also a disused pier.	Coulson 2011; E, Morgan pers obs.
England	Lowestoft, Suffolk	Pier, artificial cliff, and town buildings	1946-present. Colony on South pier was demolished in 1988, birds moved to an artificial wall provided in harbour and now nest on other piers and town buildings.	Casey and Hooton 1991, M Swindells pers. comm.
England	Sizewell rigs, Suffolk	Inshore structures	1994-present. On metal structures of decommissioned	Casey and Hooton 1991

Location	Site	Nesting habitat	Occupation and Population	Source
			power plant - due to be demolished.	
England	Morecambe Bay Gas Field, Irish Sea	Offshore oil/gas platform	1998-present. Two pairs nested in 1998, still present mainly on the central platform (220 AON in 2006)	Brown and Grice 2005
England	Scarborough, North Yorkshire	Town Buildings	mid-1990s- present. Currently nesting on natural cliffs and many buildings in the town. Spread from Natural cliffs into town	Hopper 2012
Scotland	Edinburgh	Pier	A few pairs for a couple of years (1931)	Coulson 2011
Scotland	Dunbar	Warehouse buildings	1934-1960 (structure demolished), birds then moved to natural cliff and harbour areas	Coulson 2011
Wales	Mumbles, Swansea	Mumbles pier and artificial platform	1993-present. Currently most are nesting on artificial ledges provided on Mumbles pier c.30 pairs 1993 up to 160 pairs 2011, 90 pairs now. Artificial shelving erected 2012 while renovation work was carried out to pier	Gower wildlife blog

Table 2.2 Sites where purpose made artificial nesting sites for kittiwake have been successful

Artificial nesting sites	Tyne kittiwake tower(s)	Lowestoft wall	Mumbles Shelves	Boulogne Wall	Middleton Island Tower
	 © Russel Wills	 © Mike Swindells	 © By Nilfanion - Wikimedia UK	 © Jean-Michael Sauvage	 Image adapted from Gill & Hatch 2002.
Location	Saltmeadows, Gateshead	Lowestoft harbour, Suffolk	Mumbles Pier, Swansea	Boulogne-Sur-Mer harbour, France	Middleton Island, Alaska
Sighting notes	Banks of River Tyne, on scrubland behind industrial area	Wall at entrance to fishing harbour	Shelves attached to existing pier structure	On top of sea wall within an industrial port (Loubet basin)	On old Air Force radar tower on offshore island
Materials	Radio mast structure with shelving platforms on top	Concrete wall with ledges	Wooden shelving units	Concrete wall with discrete compartments	Old radar tower modified to allow access to birds for scientific research
Height, dimensions etc.	3 Panels with ledges in triangular design. Each panel c.6m long with 8 ledges on each	Top ledges on both sides of wall, inward facing side 2 ledges (wide spacing between ledges)	Ledges on one side only. Multiple units (at least 5) installed on existing pier structure	Compartments one side only, space for 3 nests per compartment Length = 85 m	Individual shelved compartments size of one nest

Artificial nesting sites	Tyne kittiwake tower(s)	Lowestoft wall	Mumbles Shelves	Boulogne Wall	Middleton Island Tower
			3-6 shelves on each unit. c.5 - 10 m long	Compartments are 140 cm x 60 cm	
Aspect	Sites occupied on all 3 sides. NE and NW generally have more nests than the S side Breeding success is higher on NE and NW sides (These are the sides pointing towards river)	Main occupied nesting sites on landward side of harbour wall over water (N/NW facing)	All over water beneath front and rear of lifeboat station (approx. N and S facing) and along pier supports on NE and SW sides	Corner plot facing out to sea (NW and NE)	Circular, all sides occupied
Date installed	1998	1988	2012	2017	Modified in mid 1990s
Potential number of nest sites	Max record = 143 nests (2007). Space for many more nests	Max record = 259 nests (in 1995)	c.200 nests	584 nests	Over 400 pairs
Number sites occupied/ productivit y	111 nests 2019 (overall productivity = 0.79 2019)	In 2015 82 nests but raised zero chicks. 2016 only 22 nests. 2020 at end of July no birds seen nesting on wall (NB. some birds may have fledged) (E. Morgan, pers. obs.)	76 nests in 2013 (90 AON reported in 2018 but for whole Mumbles region – SMP)	In 2017 155 nests with chicks	Unknown
Known issues	Tower provided as compensatory measure due to renovation of old	Wall built as compensatory measure due to demolition of	Shelving put up in 2011/12 as temporary compensation while	Wall built as compensatory measure due to demolition of building which had nesting	Bird breeding success on the island is decreasing.

Artificial nesting sites	Tyne kittiwake tower(s)	Lowestoft wall	Mumbles Shelves	Boulogne Wall	Middleton Island Tower
	buildings along river where birds had established nesting sites. Some issues with avian predation (crows) which resulted in all breeding kittiwakes deserting the site for the 2013 breeding season Clay decoys used to attract birds initially	adjacent to pier where birds had established nest sites. Issues with gull predation (top shelves) and mammalian predation (fox lower shelves) Accessible on foot from rear	renovation work carried out on pier with established nest sites. Birds initially tried to access old nest sites beneath deterrents on pier but gradually moved to ledges.	birds established. Structure in same location as old building.	Additional food is provided for birds during the breeding season (Gill and Hatch, 2002)

Table 2.3: Purpose made artificial nesting sites for kittiwake where birds have (as yet) failed to colonise.

Artificial nesting sites:	**Boulogne Buildings and tower**	**South Shields Tower**	**Tromso kittiwake hotels**	**Finnmark kittiwake hotel**
	 © Jean-Michael Sauvage	 © Jean-Michael Sauvage	 © Tone Kristin Reiertsen	 sketch of design
Location	Boulogne-Sur-Mer harbour, France	South Shields, UK	Tromsø, Norway	Berlevåg, Finnmark, Norway
Sighting notes	Shelves on existing tower of ferry terminal located over water within harbour channel	Banks of River Tyne, on dockyard/ industrial area	'Artificial nests' attached to the side of a building on end of pier	Outside town on coast
Materials	Wooden shelving units, on side of existing building	Radio mast structure with shelving platforms on top	Wooden individual shelves on building	Wooden structure with open shelves
Height, Dimensions etc.	Ledges of varying size	4 Panels with ledges in rectangular design. Each panel has 7 ledges on each	Nests installed on a building owned by Tromsø Havn at the "SørSjeteen" Dimensions unknown	Exact dimensions unknown
Aspect	South and East sides of building	4-sided design	Aspect unknown – on pier	Aspect unknown – on coast
Date installed	2017	2014	2018	2019

Artificial nesting sites:	Boulogne Buildings and tower	South Shields Tower	Tromso kittiwake hotels	Finnmark kittiwake hotel
Potential number of nest sites	unknown	Unknown (similar to Gateshead tower)	30 nests	320
Number sites occupied/ productivity	Zero	Zero	No nests established (2019)	No nests established (2019)
Known issues	Ledges added as compensation for renovation work on areas of building where birds already nested. Sites were not adopted by birds, most likely due to issues with sun exposure (JM Sauvage pers. comm.) Small tower in water channel was also constructed in this area and is believed to be unsuccessful.	Tower was built in 2014 but was never used by birds and has now been removed.	No birds on sites in 2019 or 2020 breeding seasons (S. Dalsgaard pers. comm.)	Nests from town were moved onto the structure to encourage relocation, but birds showed no interest in site as of 2020. A Different design is being considered.

2.5.1.4 The compensation measures proposed for Hornsea Four aim to benefit the FFC SPA kittiwake feature (i.e. provide additional recruits into the east Atlantic biogeographic population), However, it is beyond the control of the project to guarantee birds produced by the Artificial Nesting Structure (ANS) would recruit into the FFC population. Factors such as proximity to the FFC SPA site are likely to increase the likelihood of birds recruiting into that population, but due to the large size of the colony at FFC the proportion of available nest sites for new recruits will be lower due to density-dependent effects regulating colony size (Coulson 2011), therefore young birds may be more likely to recruit into smaller more rapidly expanding populations elsewhere. Kittiwake colonies are thought to act as a metapopulation with high interchange of recruits between colonies breeding in the North Sea and a high degree of mixing of these population at wintering sites (Ruffino *et al.* 2020, Frederiksen *et al.* 2012). As such birds produced at an ANS but not recruiting into the FFC SPA population does not preclude fulfilling the requirement to preserve the coherence of the network of kittiwake Natura 2000 sites as it benefits the wider North Sea population of kittiwake generally. The search area has initially been limited to the English southern North Sea as there is a preference for compensation to be located close to the impact where possible. The provision of artificial nest habitat could boost the wider North Sea kittiwake population if breeding success at these new sites averaged more than 0.8 chicks per nest (Coulson 2017). New colonies would also need to be large enough to buffer the effects of demographic stochasticity i.e. >40 nests (Wright 1995) and to increase the chances of attracting new recruits.

Conclusion	Context
Although kittiwake populations have declined at many UK sites, there are a number of sites where populations seem to be doing well (or are at least stable) particularly in the Southern North Sea region.	To increase likely success of colonisation and subsequent breeding success, new nesting structures should be close to areas where populations and productivity trends are stable or increasing. To maintain numbers in the long term, it will be necessary for productivity to be over 0.8 chicks per year at the new site.

Table 2.4: Population trend Apparently Occupied Nests (AON) for English east coast kittiwake colonies between 2010-2021 (for colonies with two or more counts within the last 10 years). Census counts are those submitted to SMP database unless otherwise stated.

Colony	Type	Number of years	Most recent count (year)	Linear trend (corr) 2010	Trend
Farne Islands SPA	Natural	9	3,158 (2018)	-0.41	DEC
Coquet Island SPA	Natural	10	439 (2019)	0.92	INC
River Tyne Natural	Natural	6	246 (2015)	0.48	INC
River Tyne Urban	Urban	6	1,011 (2015)	0.61	INC
Marsden Bay	Natural	7	3149 (2019)**	0.29	INC
Hartlepool	Urban	4	422 (2021)*	0.82	INC
Saltburn Coast	Natural	8	1,110 (2020)	-0.49	DEC
Staithes to Sandsend	Natural	2	1,260 (2018)	N/A	N/A
Boulby Cliffs	Natural	8	1440 (2020)	-0.70	DEC

Colony	Type	Number of years	Most recent count (year)	Linear trend (corr) 2010	Trend
Scalby to Rocky Point	Natural	4	0 (2019)	-0.98	DEC
Scarborough to Osgodby Point Natural	Natural	12	1,963 (2021)	0.40	INC
Scarborough to Osgodby Point Urban	Urban	11	846 (2021)	0.96	INC
Flamborough and Filey Coast SPA	Natural	2	5153 (2017)	N/A	N/A
Lowestoft (Town)	Urban	9	768 (2021)*	0.90	INC

Counts from Orsted 2012 surveys, ** Durham Bird Club report 2019.

Table 2.5: Productivity trends from English kittiwake colonies between 2015 to 2019. Highlighted cells show colonies whose reproductive rate is currently at or above sustainability threshold identified by Coulson (2017) (* indicate colonies where the most recent data are 2-3 years old)

SMP Site	Type	Number of years	Prod. 5yr Mean	Linear trend value (correlation)	Visual Trend	At or above threshold for sustainable pop. (Coulson 2017)
Coquet Island SPA	Natural	5	1.07	-0.82	↓	Yes
River Tyne to Seaton Sluice	Mix	5	0.92	0.00	→	Yes
(Tyne Urban Only)	(Urban)	(5)	(08.89)	(0.02)	(→)	(Yes)
Flamborough and Filey Coast SPA	Natural	5	0.56	-0.42	↓	No
Lowestoft (Town)	Urban	3*	0.97	0.98	↑	Yes
St Bees Head and Town	Mix	5	0.45	-0,58	↓	No
Lundy	Natural	4	0.45	0.33	↑	No
Isles of Scilly SPA	Natural	3	0.12	-0.78	↓	No

Table 2.6:Productivity trends from English kittiwake colonies between 2010 to 2019. Highlighted cells show colonies whose reproductive rate is currently at or above sustainability threshold identified by Coulson 2017 (* indicate colonies where the most recent data are 2-3 years old)

SMP Site	Type	Number of years	Prod. 10yr Mean	Linear trend value (correlation)	Visual Trend	At or above threshold for sustainable pop. (Coulson, 2017)
Coquet Island SPA	Natural	10	1.17	-0.73	↓	Yes
Farne Island SPA	Natural	6*	0.87	-0.76	↓	Yes
River Tyne to Seaton Sluice	Mix	10	0.96	-0.50	↓	Yes
(Tyne Urban Only)	(Urban)	(10)	(0.96)	(-0.61)	(↓)	(Yes)
Flamborough and Filey Coast SPA	Natural	8	0.58	-0.42	↓	No
Lowestoft (Town)	Urban	8*	1.08	-0.48	↓	Yes
Straight Point and Otterton Ledge to Ladram Bay	Natural	5	0.76	0.99	↑	No
Mounts Bay Cornawal	Natural	4*	0.18	-0.53	↓	No
Isle of Scilly SPA	Natural	3	0.12	-0.78	↓	No
St. Agnes Island	Natural	4	0.36	-0.95	↓	
Lundy	Natural	9	0.51	-0.17	↓	No
St Bees Head and Town	Mix	10	0.59	-0.34	↓	No

2.5.2 Foraging areas used by kittiwakes in the North Sea

2.5.2.1 The reason for declines in kittiwake productivity has been strongly linked to food availability, specifically sandeel, in the northern UK (Furness and Tasker 2000, Oro and Furness 2002, Furness 2007, Frederiksen *et al.* 2004). The largest UK population of kittiwakes occurs along the Flamborough and Filey Coast (see **Table 2.4**) with birds nesting at this site primarily foraging out towards the Dogger Bank, which holds a large population of sandeels, but is subject to fishing pressures (Lindegren *et al.* 2018). Fishing effort has recently been linked to reduced breeding success of kittiwakes at the FFC SPA, which concurs with previous studies elsewhere showing reduced breeding success and survival of kittiwake associated with a decline in sandeel abundance in parallel with fishing pressure (Carroll *et al.* 2017). The relationship between kittiwake productivity and prey at FFC SPA is also covered in depth in the **Supporting Evidence for Kittiwake Prey Resource** report prepared by Hornsea Three in response to the Secretary of State's Minded to Approve Letter (**Appendix C to the Applicant's Response**).

2.5.2.2 Though sandeel are thought to be an important part of birds' diet in the southern North Sea i.e. sandeels comprise 60% of diet in breeding birds (Furness and Tasker 2000), their diet across this region does however appear to be more varied (with clupeids and gadids available as alternative food sources; M. Swindells pers. comm). In the eastern part of the southern North Sea, stability at colonies in Denmark and Germany has been attributed to the likelihood that kittiwakes differ in their main food source from the well-studied colony on the Isle of May (Lerche-Jørgensen *et al.* 2012). Moreover, the alternative prey species (Small Sandeel *Ammodytes tobianus* and the Great Sandeel *Hyperoplus lanceolatus*) or fishery discards these populations of breeding kittiwake may rely on as a food source may be less affected by sea temperatures (Lerche-Jørgensen *et al.* 2012). Some kittiwake colonies in southern England are also considered to be less likely to be dependent on sandeels than those farther north (McMurdo-Hamilton 2016).

2.5.2.3 Sandeels in the North Sea can be divided into a number of more or less reproductively isolated sub-populations, due to the short period that larvae drift and the dependency of later life stages on specific areas of sand, and there has been evidence of local depletions in some regions (ICES). ICES has divided the North Sea into seven management regions. Kittiwake are constrained to forage within range of their breeding colony and are therefore reliant on these specific sandeel sub-population areas. Trends in breeding success of areas reliant on the same food stocks generally show similar population trends (Frederiksen *et al.* 2005, Olin 2020). Interestingly Olin *et al.* (2020) found that the population trends associated with colonies in Lowestoft and East Yorkshire do not appear to be as similar as expected given their proximity. This may suggest birds are reliant on different local food sources. Diet data from Lowestoft show birds are feeding on sandeel, with some clupeids (e.g. herring, sprat), and gadids (e.g. cod, pollock) (M. Swindells pers. comm.). A small number of foraging tracks have been collected at Lowestoft and kittiwakes appear to be foraging close to Lowestoft (M Swindells pers comm). A shorter foraging range is generally associated with higher productivity (Daunt *et al.* 2002). Kittiwakes from Bempton/Filey are foraging towards the Dogger Bank, an area with a sizeable sandeel fishery (see **Figure 2.1** and **Figure 2.2**). Preliminary results from diet samples collected as part of the RSPB FAME/STAR tracking studies across UK colonies indicates geographic variation in kittiwake diet across their range, with the probability of samples containing sandeel declining with latitude with increasing proportions of clupeids and gadids found in these regions (Wilson 2021).

2.5.2.4 Kittiwakes are likely to be subject to high levels of intra-specific competition at very large colonies (Wakefield *et al.* 2017). Therefore creating small new colonies in locations away from (i.e. not at or extremely close to FFC SPA) would be likely to increase breeding success of birds in new artificial colonies as it would reduce competition for food (providing an adequate stable food supply is available within the foraging range of birds).

2.5.2.5 **Figure 2.1** shows the location of UK east coast kittiwake colonies with 50% core foraging range and 95% home range of Kittiwake in the North Sea reproduced from UK-level utilisation distributions as derived by Cleasby *et al*. (2018) from tracking studies of breeding birds at various UK colonies and **Figure 2.2** shows sandeel habitat for the same region. The two maps show distribution of foraging kittiwakes matches closely to the major areas of sandeel habitat, however, there are a few potential sandeel locations within the southern North Sea where kittiwake foraging hotspots have not yet been recorded. There is strong evidence that kittiwakes in the southern North Sea are limited by nesting habitat availability (Coulson 2011). Providing artificial nest sites within this area could potentially open some of these locations to breeding kittiwake.

2.5.3 Additional location factors to consider

2.5.3.1 Sites identified as good potential locations based on population and/or productivity trends need to meet additional biological and logistical requirements to be considered a feasible location for an artificial structure. These factors include:

- Prey availability (and diversity) within foraging range;
- The size of nearby colonies e.g. to weigh up competition versus source of recruits (see **Figure 2.2** and **Figure 2.4**);
- Proximity to wind farms[1] or other infrastructure/development;
- Proximity to attractant features (e.g. Fish Quays, Inflows/Outflows);
- Habitat opportunities and constraints i.e. Natural England have advised (3rd September meeting) that SPAs not designated for kittiwake are a suitable potential option;
- Availability of waterfront locations suitable for construction; and
- Accessibility for maintenance and monitoring.

2.5.3.2 Sites could be ranked based on these criteria to narrow down search areas. The scale of the search areas could then be narrowed to specific sites within a chosen area based on fine scale features (see **Appendix C** of this document), which should also influence the design of artificial nesting structures.

[1] Defining acceptable distances required to avoid the new site potentially increasing collision rates from existing nearshore/offshore wind developments is challenging. The greater the distance and the more inappropriate the habitat at the Offshore Wind Farm (OWF) is for foraging kittiwakes, the better, though birds may transit an OWF en route to feeding grounds. Tracking data could assist in establishing the most likely flight paths of birds to/from colonies, however, currently tracking data from most colonies is limited. Examining overlap of core foraging areas (Cleasby *et al* 2018) with existing OWFs within mean foraging range from proposed colony sites could provide qualitative information to aid decision making. At Teesmouth, there is a colony of kittiwakes on a Conoco-Phillips jetty (c. 4 km from the Tees Wind Farm) which has grown during the period of construction and operation of the windfarm. Post-construction monitoring has found a reduction in numbers of kittiwakes using the area within the windfarm footprint and no collisions were observed in the period of 2015-2016 (Percival 2016).

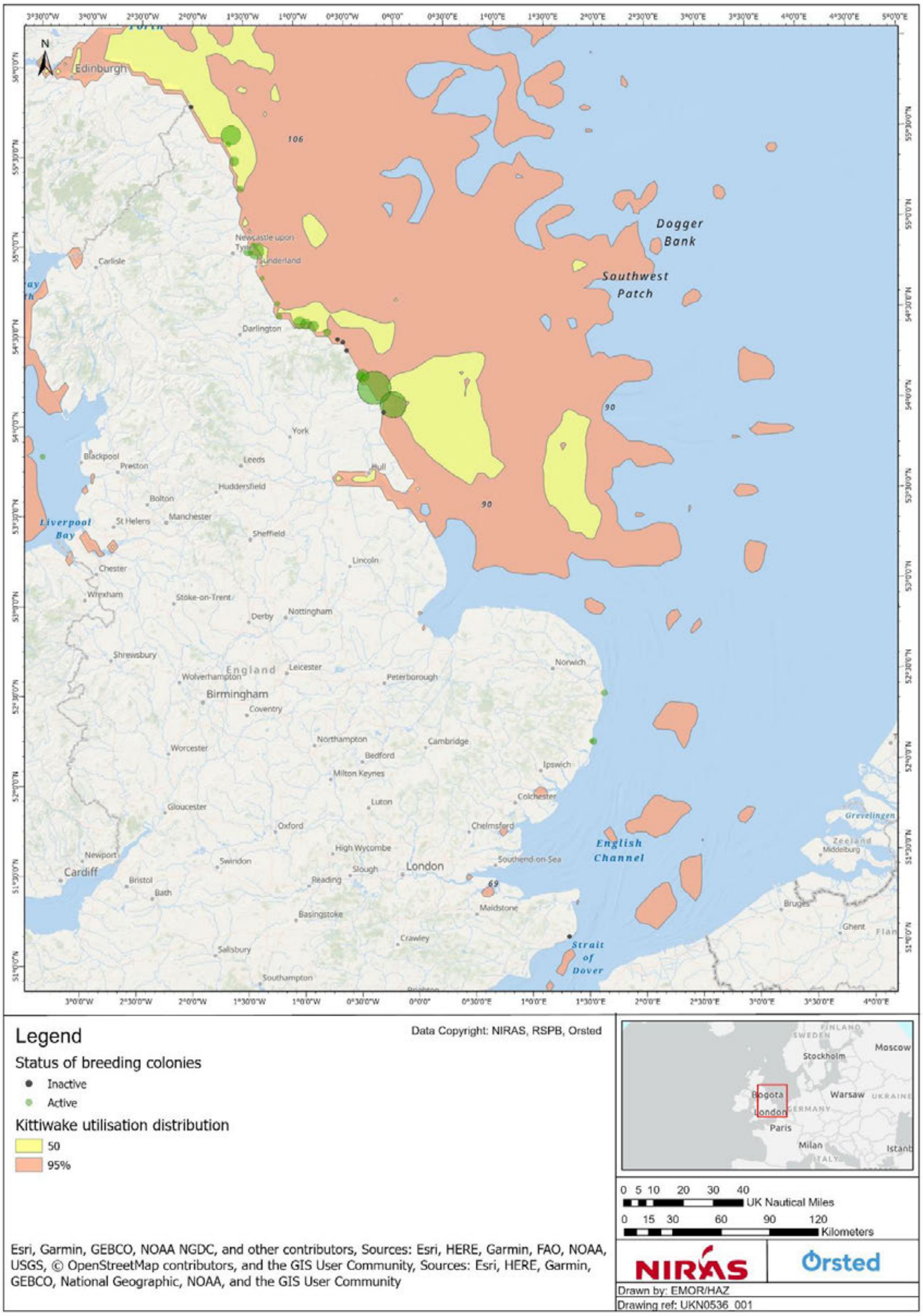


Figure 2.1: Location of UK east coast kittiwake colonies with 50% core range and 95% home range of Kittiwake in the North Sea reproduced from UK-level utilisation distributions as derived by Cleasby *et al.* (2018) from tracking studies of breeding birds at various UK colonies.

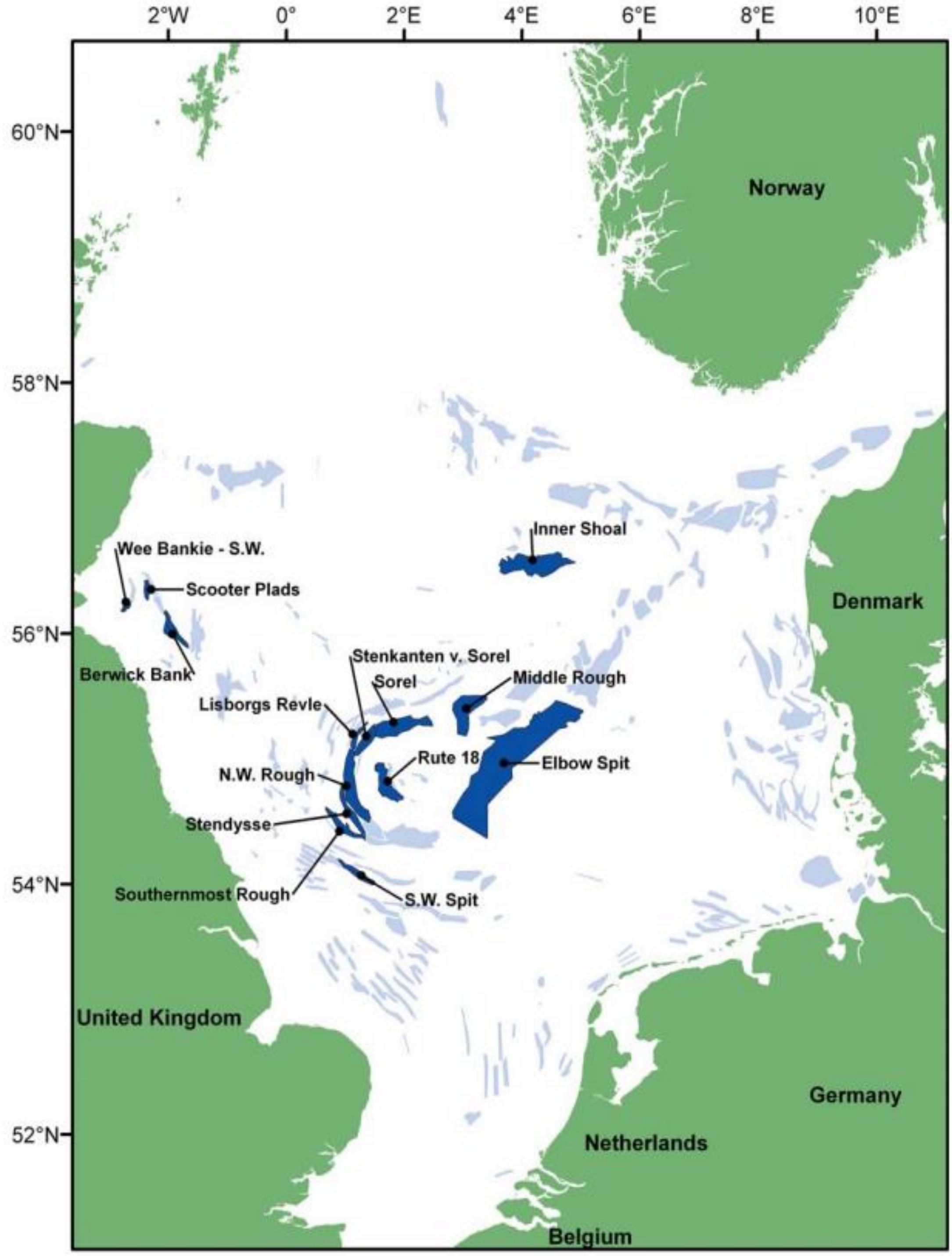


Figure 2.2: Sandeel habitat areas (areas with potentially high density of non-buried sandeel) and the locations of the fishing grounds (reproduced from Jensen *et al.* 2010).

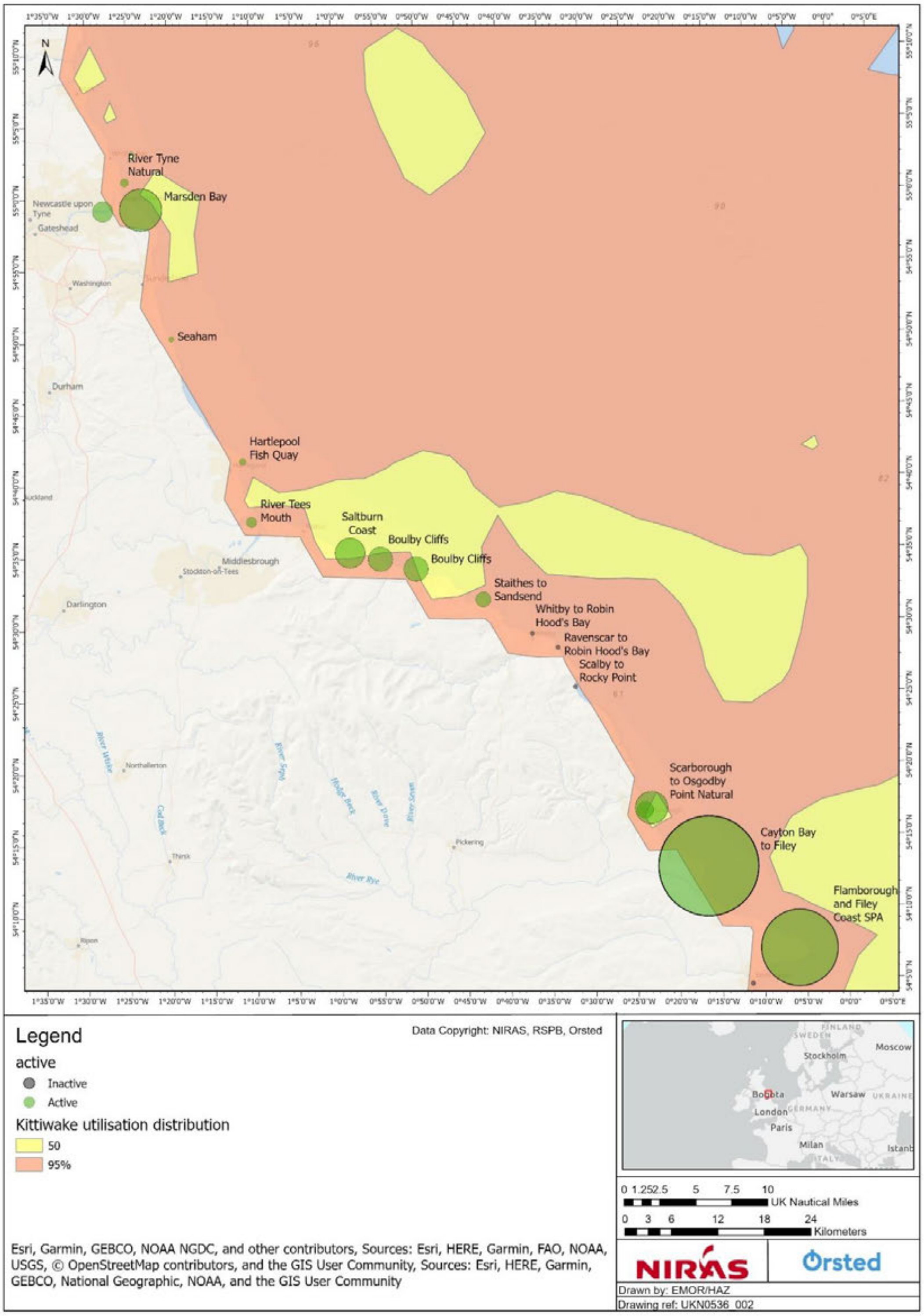


Figure 2.3: Location of north-east UK kittiwake colonies alongside 50% core range and 95% home range of Kittiwake in the North Sea reproduced from UK-level utilisation distributions as derived by Cleasby *et al.* (2018). Relative population sizes (most recent census count from SMP data up to 2019) are shown by size of points.

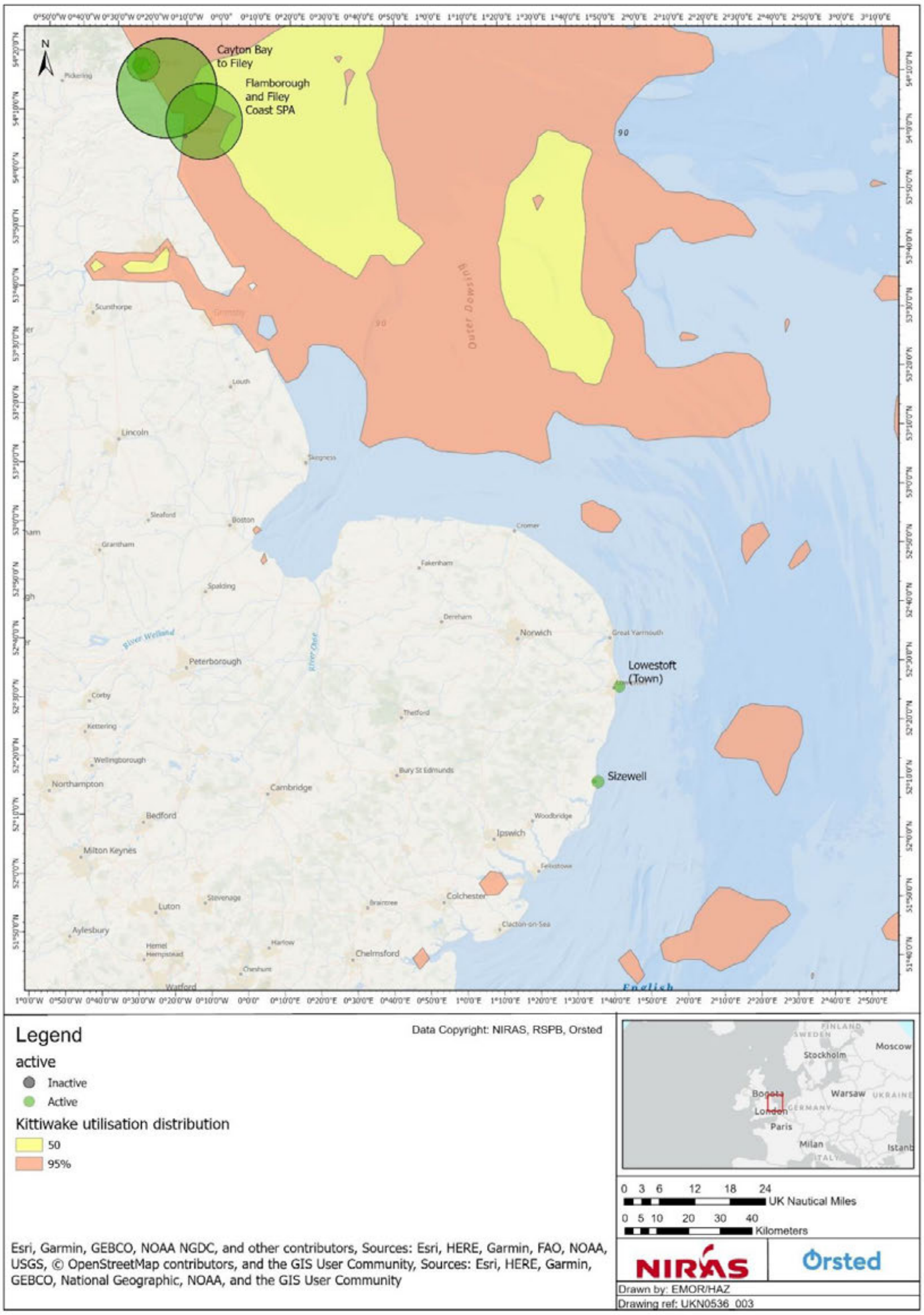


Figure 2.4: Location of UK south-east kittiwake colonies alongside 50% core range and 95% home range of Kittiwake in the North Sea reproduced from UK-level utilisation distributions as derived by Cleasby *et al.* (2018). Relative population sizes are shown by size of points.

2.5.4 Sandeel / food stock status in the North Sea

2.5.4.1 The reason for declines in kittiwake productivity has been strongly linked to food availability, specifically sandeel, in the northern UK (Furness and Tasker 2000, Oro and Furness 2002, Furness 2007, Frederiksen *et al.* 2004). The largest UK population of kittiwakes occurs along the Flamborough and Filey Coast (see **Table 2.4**) with birds nesting at this site primarily foraging out towards the Dogger Bank, which holds a large population of sandeels, but is subject to fishing pressures (Lindegren *et al.* 2018). Fishing effort has recently been linked to reduced breeding success of kittiwakes at the FFC SPA, which concurs with previous studies elsewhere showing reduced breeding success and survival of kittiwake associated with a decline in sandeel abundance in parallel with fishing pressure (Carroll *et al.* 2017). The relationship between kittiwake productivity and prey at FFC SPA is also covered in depth in the Supporting Evidence for Kittiwake Prey Resource report prepared by Hornsea Three in response to the Secretary of State's Minded to Approve Letter (**Appendix C to the Applicant's Response**).

2.5.4.2 Though sandeel are thought to be an important part of birds' diet in the southern North Sea i.e. sandeels comprise 60% of diet in breeding birds (Furness and Tasker 2000), their diet across this region does however appear to be more varied (with clupeids and gadids available as alternative food sources; M Swindells pers. comm). In the eastern part of the southern North Sea, stability at colonies in Denmark and Germany has been attributed to the likelihood that kittiwakes differ in their main food source from the well-studied colony on the Isle of May (Lerche-Jørgensen *et al.* 2012). Moreover, the alternative prey species (Small Sandeel *Ammodytes tobianus* and the Great Sandeel *Hyperoplus lanceolatus*) or fishery discards these populations of breeding kittiwake may rely on as a food source may be less affected by sea temperatures (Lerche-Jørgensen *et al.* 2012). Some kittiwake colonies in southern England are also considered to be less likely to be dependent on sandeels than those farther north (McMurdo-Hamilton 2016).

2.5.4.3 Sandeels in the North Sea can be divided into a number of more or less reproductively isolated sub-populations, due to the short period that larvae drift and the dependency of later life stages on specific areas of sand, and there has been evidence of local depletions in some regions (ICES). ICES has divided the North Sea into seven management regions. Kittiwake are constrained to forage within range of their breeding colony and are therefore reliant on these specific sandeel sub-population areas. Trends in breeding success of areas reliant on the same food stocks generally show similar population trends (Frederiksen *et al.* 2005, Olin 2020). Interestingly Olin *et al.* (2020) found that the population trends associated with colonies in Lowestoft and East Yorkshire do not appear to be as similar as expected given their proximity. This may suggest birds are reliant on different local food sources. Diet data from Lowestoft show birds are feeding on sandeel, with some clupeids (e.g. herring, sprat), and gadids (e.g. cod, pollock) (M Swindells pers. comm.). A small number of foraging tracks have been collected at Lowestoft and kittiwakes appear to be foraging close to Lowestoft (M Swindells pers comm). A shorter foraging range is generally associated with higher productivity (Daunt *et al.* 2002). Kittiwakes from Bempton/Filey are foraging towards the Dogger Bank, an area with a sizeable sandeel fishery (see **Figure 2.1** and **Figure 2.2**). We understand diet samples have been collected from Bempton/Filey but have yet to be analysed.

2.5.4.4 Kittiwakes are likely to be subject to high levels of intra-specific competition at very large colonies (Wakefield *et al.* 2017). Therefore creating small new colonies in locations away from (i.e. not at or extremely close to FFC SPA) would be likely to increase breeding success of birds in new artificial colonies as it would reduce competition for food (providing an adequate stable food supply is available within the foraging range of birds).

Conclusion	Context
Birds may have higher foraging (and subsequent breeding) success in areas where there is less competition, both from fisheries and other kittiwake colonies.	A structure may be more successful if there is a variety of prey species within range that are not subject to intense pressure from fisheries. Structures may have a higher chance of success (i.e. productivity) at increasing distances from very large colonies e.g. FFC SPA population.

2.6 Optimal design specification for kittiwake artificial nest sites

2.6.1 Natural nest sites characteristics / preferences

2.6.1.1 At natural sites, kittiwakes show a preference for the mid to lower sections of a cliff with steep vertical faces and small ledges on which to make their nests. Substantial nests are made from mud and vegetation/seaweed in order to hold the eggs/chicks (Cullen 1957). Kittiwakes are adapted to nest on much narrower cliff ledges than other seabirds (Cullen 1957, Coulson 2011). This helps them avoid terrestrial and aerial predators, notably larger gulls do not appear to be able to land on very small ledges (Cullen 1957).

2.6.1.2 Natural nest site characteristics are summarised in **Table 2.7**. The slope of horizontal ledges appears to be of less importance as kittiwakes build substantial nest structures, but more horizontal platforms appear to be more successful than steeply sloped ledges, with birds preferring a range of 16° - 25° (Olsthoorn & Nelson 1990). A small overhang or roof cover above the nest is also a common feature of natural nests and may enhance productivity (Kidlaw 1999, Olsthoorn & Nelson 1990). The mechanism behind this may be to prevent rain entering the nest (Olsthoorn & Nelson 1990) or it could reduce predation pressure from aerial predators. From examining various artificial nesting sites as part of this report, it appears that birds tend to avoid building nests on the top shelves of these structures (E Morgan, pers. obs). Sites where the top ledges are open, and the top of the structure is wide (i.e. wall at Lowestoft) have reported issues with large gull predation (M Swindells pers. comm.).

Table 2.7: Natural nest site preferences of kittiwakes reported in scientific literature.

Study	Coulson (2011)	Kidlaw (1999)	Olsthoorn & Nelson (1990)
Geographical location	R. Tyne, England	St George Is, Alaska	Bullers of Buchanan, Scotland
Width x length of ledge	Min = 8 cm by 8 cm	Mean width 21.4 cm (±8.2) by mean length* 38.8 cm (±23.8)	30 cm length by 20 cm width. Can be narrower than nest but rarely longer than size of nest i.e. <50 cm

Study	Coulson (2011)	Kidlaw (1999)	Olsthoorn & Nelson (1990)
Other ledge features	-	Slight overhang. Back wall 82.4°cm (±14.7)	Roof may be beneficial Dry site important. No sites were exposed on all 3 sides
Height	-	3-30 m above sea level	Above wave spray height
Availability of adjacent perching space	Not mentioned	Not mentioned	Approx. 50% of nests had perching space for adult to roost next to nest the off-duty adult to stand beside the nest
Density of kittiwakes in surrounding area	High (within 5 ft of another nest)	High (figures not specified)	High (6-15 birds within a 2 m radius)

* Ledge length—the maximum horizontal distance between points where the ledge merges with the back wall on either side of the nest site.

2.6.2 Design Considerations for kittiwake artificial nests

2.6.2.1 In Spain and Portugal, the few breeding kittiwakes only nest on north-facing cliffs where sites are in the shade (Coulson 2011). Problems with colonisation of artificial shelves at a site in France are believed to be due to issues with sun exposure of the south facing ledges added to a harbour building (see **Table 2.3**, JM Sauvage pers. comm.).

2.6.2.2 Around the UK, prevailing winds and storm conditions may be of more importance to nest site selection. Wind strength affects kittiwake attendance at colonies early in the season, with fewer birds present as wind speed increases (Coulson 2011). The occurrence of storms and prevailing weather conditions can disproportionately affect the breeding success of seabirds nesting on different sides of the same island (e.g. Newell *et al.* 2015).

2.6.2.3 Providing artificial sites facing different directions may provide a buffer in the event of unfavourable weather conditions. Artificial nest sites which have small partitions between nests (e.g. Middleton Island, Alaska and Boulogne Wall, France) are reported to be beneficial in buffering birds from detrimental weather conditions. Olsthoorn & Nelson (1990) found birds preferred nest sites which were less exposed, i.e. had more than one wall consisting of back and sides.

2.6.2.4 Of the artificial nesting structures examined for this report, there does not appear to be a particular design favoured over another in terms of attracting birds to nest at these sites (see **Table 2.2**). However, all the successful designs have a few key features in common; narrow ledges with steep back walls, are high enough for birds to feel safe (i.e. minimise disturbance), have features which limit exposure to adverse weather, and are in view of the sea. Further details of these design specifications can be found in **Table 2.3** and **Table 2.2**). Minimising risk of predation is also key as birds have been known to abandon sites where predation pressure is too high (D Turner pers. comm.).

2.6.2.5 Sites where success has been limited could be due to design or location (see **Table 2.3**). Only one location exists where more than one design was trialled in the same area, Boulonge-Sur-Mer, which has a wall and a modified building/ tower structure. Ledges added to buildings were too exposed to the sun and were not adopted by birds, whereas the wall structure (which is NW and NE facing) was highly successful. An unsuccessful design in Finnmark, Norway is most likely due to the lack of backing to the structure leaving birds too exposed to the elements.

2.6.2.6 The second kittiwake tower built on the River Tyne was a similar design to the first tower, yet it was unsuccessful in attracting birds. Photographs of this tower suggest different materials were used which stand out from the surrounding environment (brightly stained timber was used for the nesting platforms). Perhaps, like many other birds, kittiwakes are wary of strange new looking structures. Having structures which blend in with the surrounding area may be important. However, this tower was also located away from existing kittiwake nesting sites and away from any other building like structures (though it was located between a natural site and the urban nesting sites upstream), which may make it less attractive to birds (see **Appendix B**: Successful and unsuccessful artificial nesting sites).

2.6.2.7 Location seems to be more important than building materials. Areas where artificial sites have been adopted quickly (often within a year or two of construction) have been sites where the new structure was built directly adjacent (or very close to) a site which had been demolished/made inaccessible. In many of these sites, birds were also present nesting on other similar structures within the harbour/town areas. Social environment appears to have a greater influence on adoption of artificial ledges than physical characteristics (Kidlaw 1999).

2.6.2.8 Playing kittiwake calls and setting up dummy nests and birds at a site has been suggested as a way to entice birds into a new structure (Coulson 2011, D. Turner, pers comm.) but remains largely untested. Few of the existing successful artificial sites examined (**Table 2.2**) have used these methods to encourage birds to nest.

2.6.3 Protection of Visitors and Kittiwakes

2.6.3.1 Kittiwakes at St. Abb's Head, East Scotland have shown reduced nesting success and even nest failure linked to human disturbance (Beale and Monaghan, 2004, 2005). The structure will need to be secure from unwanted visitor access (for health and safety of visitors and kittiwakes) but this will probably only comprise appropriate security fencing around the perimeter of the installation. The need for wider exclusion would need to be considered if there were a risk of disturbance of the site, although elevated designs, and likely location (away from human habitation) would likely render this unnecessary. The need for any wider exclusion will probably depend on the specific setting.

2.6.3.2 Predator deterrents have been installed on some of the existing artificial nest sites. The Tyne kittiwake tower has spikes on the top of the structure to deter avian predators from landing. The wall at Lowestoft had wire/fencing installed on parts of the pier to prevent foxes from accessing the wall.

Conclusion: Key Features for Artificial Nest Sites

- High and steep sided, narrow horizontal ledge, small roof
- Inaccessible to predators
- Located close to water, facing out to sea
- Materials which fit in with surroundings
- Not too exposed to adverse weather
- Presence of other breeding kittiwakes

2.6.4 Design Specification Options

2.6.4.1 The overall design of an artificial nesting structure for kittiwakes can be flexible provided a set of critical physical features are met. Various designs (using a range of materials) have been successful ranging from shelves attached to existing structures, to purpose-built towers and walls. In terms of increasing the attractiveness to kittiwakes (i.e. increasing the likelihood of colonisation), design options are likely to be secondary to choosing the correct location. A design which fits in with the structures and locations birds are already using at an existing site should be key in informing the design of a structure. Temporary design features could be added to structures to encourage recruitment i.e. decoy nests/birds and audio systems to play kittiwake calls to attract birds in.

2.6.4.2 Certain design features could increase productivity at a site once established e.g. Walls/partitions between groups of nests and a small overhang/roof to buffer against weather conditions, and additional predator deterrents.

2.6.4.3 By ensuring that the structures are designed to incorporate key specifications, the compensation measure will increase changes of success and support resilience of the measure. The following sections provide detail, and associated evidence for potential options to include in the initial design. Structural design has formed an integral component of discussions within the Hornsea Three Offshore Ornithology Engagement Group (OOEG) and lessons learned from these discussions will be applied to Hornsea Four design components.

Critical Features

2.6.4.4 Physical design elements should compromise:

- Horizontal ledges 20 cm width by 40 cm length per nest
- Vertical back wall
- Height above ledge >40 cm

Location

- Nest adjacent to / above harbour waters / sea
- >2 m above ground/mean high water level

- Avoid faces which would be overly exposed to adverse weather e.g. strong winds, rain or sun depending on locality

Optional: design features

2.6.4.5 A range of potential structures and materials could incorporate the key design features to provide artificial sites appropriate for kittiwake nests. Additional features could be incorporated to enhance the monitoring, maintenance, and management potential of these structures. These options are detailed in **Figure 2.5**. All design structures should be positioned in locations which would allow visibility and access for monitoring purposes (see **Section 2.13**). However, a more complex design structure could reduce disturbance to birds during research/monitoring activities and would provide greater opportunities for additional research projects.

Anti-predation features

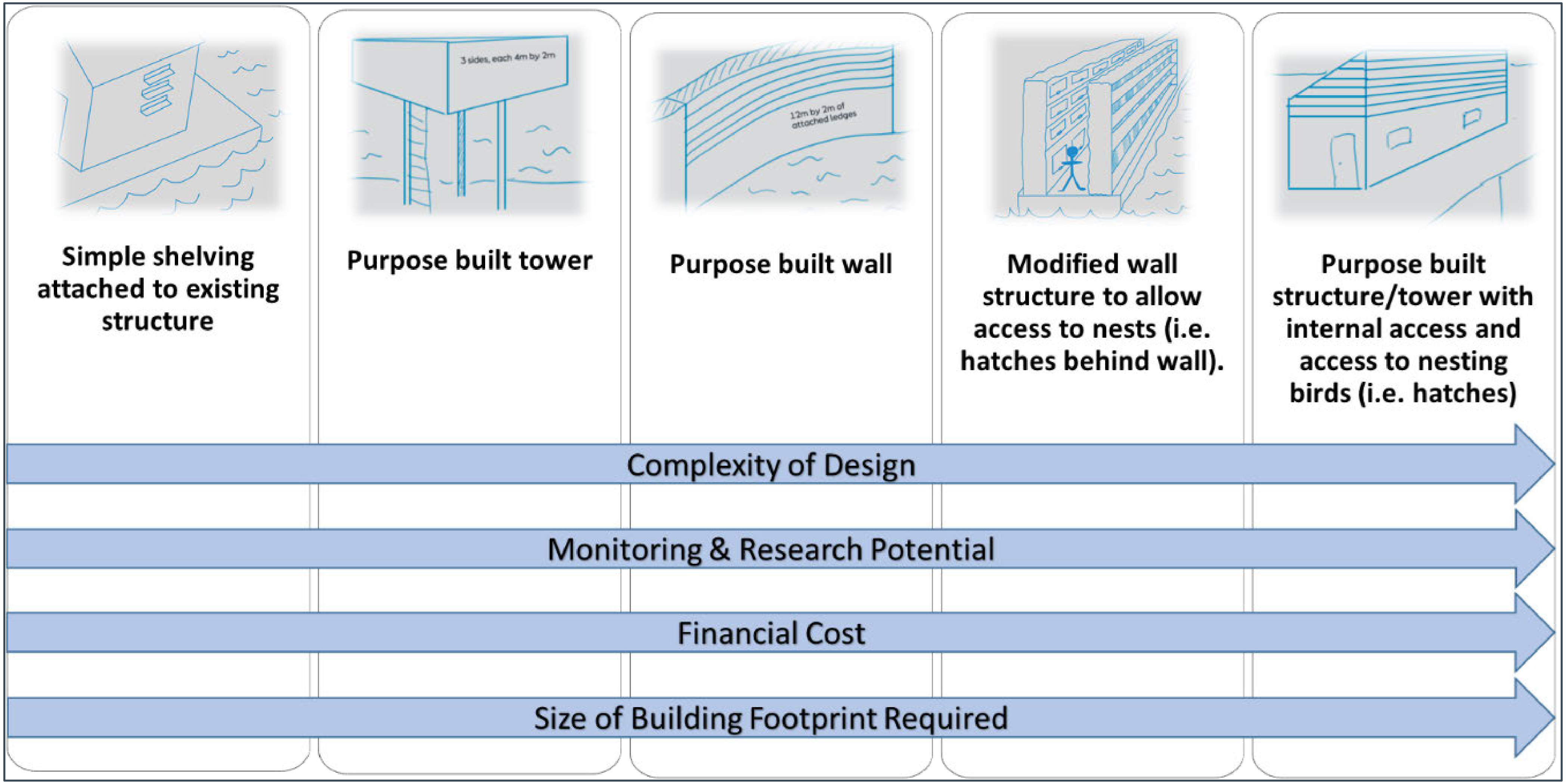
2.6.4.6 Initial nesting structure design will incorporate features aimed at preventing avian and/or mammalian predation i.e. steep vertical walls and built at a height where ground predators should not be an issue. However additional features could be added to designs to reduce predation pressure on the colony.

Avian predator deterrents

2.6.4.7 Large gull species, such as herring gull and lesser black-backed gull, are known predators of kittiwake chicks and eggs (Coulson, 2011). Their presence at a kittiwake colony can also cause unrest of breeding kittiwakes. The design of the artificial nesting structures will attempt to discourage large gulls from landing on the structures (i.e. no flat roof to land on). However, some adaptations may need to be added to the structures if it is found that the initial design has not prevented large gulls from landing (see adaptive management section). A review of urban gull management was undertaken by Calladine *et al.*, (2006) on behalf of the Scottish government, and presents a number of potential methods which could be added to the structure initially or as adaptive management. One common practice is the addition of spikes to the top of the structure to deter avian predators from landing.

2.6.4.8 Spikes have been used with success to deter lesser black-backed gulls from nesting in a housing estate in Kilmarnock (Scotland), by placing these at precise favoured nesting locations on approximately one-fifth of the houses and bungalows on the estate (Wellpark Action Group, pers. comm. referenced via Calladine *et al.*, (2006). This method has also been successfully installed on the Tyne kittiwake tower to prevent large gulls from landing on the structure. Consideration will be given to avoid any potential implications to kittiwakes themselves as a result of large gull deterrents.

Figure 2.5: Design options for artificial kittiwake colonies



Mammalian predator deterrents

2.6.4.10 As potential design of the artificial kittiwake nesting structures remains unrestricted and the exact location yet to be determined, there is a potential that the structure could be reached by mammalian predators. This was shown to be the case and the subsequent causation of mortality for breeding kittiwake along the breeding wall at Lowestoft (Furness *et al.*, 2013) when a fox accessed the breeding ledge. As a result of this incident, wire fencing was added to the nesting wall to prevent access. Similar adaptations could be made to a wall-based design that without anti predator adaptions, may allow access to ledges.

2.6.5 Methods to enhance chances of initial colonisation

2.6.5.1 Further to the initial design options listed above, other methods to increase chances of initial colonisation could be incorporated at the design stage. Below are a number of potential methods which have been widely used across multiple seabird conservation programmes globally (Friesen *et al.*, 2017) and may assist this compensation measure.

Playback

2.6.5.2 Playing calls of kittiwakes at a newly established site has been suggested as a way to entice birds to colonise new nesting structures (Coulson, 2011) but remains untested. The kittiwake hotels set up in Tromsø harbour are using tape lures to attract birds, however no birds have yet been recorded nesting (though the structures were only put in place in 2019) (Markusson, 2020).

Decoys

2.6.5.3 Models of conspecifics can work well for colonial breeding species that are attracted to nesting locations by the presence of their own species (Evans and Cash, 1985; Podolsky 1990). Visual cues are of relevance to kittiwake as the species is diurnal, attending the colony during the day, and therefore using visual stimuli to locate nesting locations. Noting the differences in breeding biology between gulls and terns, Jeffries and Brunton (2001) found that decoys (with and without a playback stimulus) attracted 80% more New Zealand fairy terns than the control treatment which used no decoys or calls. Decoys have previously been used at artificial kittiwake colonies. Turner (2010) mentions kittiwakes were lured to the Tyne tower by clay decoys and disused nests placed on the ledges but does not comment on the success of these methods. The kittiwake hotels set up on the side of buildings in Tromsø harbour are using tape lures to attract birds, however no birds have yet been recorded nesting (though the structures were only put in place in 2019) (Markusson 2010). In Finnmark, Norway existing nests were moved onto the new artificial structure, but this failed to attract birds away from their nest sites within the town (Wormdal 2020). Enhancing a colony by providing artificial nest sites on a structure where nesting space is limited (e.g. a pier) is more likely to increase the chance of successfully attracting prospecting birds.

Nests

2.6.5.4 Real nests (obtained from old, unused nests, or from birds displaced from urban settlements) or fake nests could be used to entice potential breeders to the artificial nesting structure and was proposed as a potential method during the relocation of the Baltic Flour Mill kittiwakes. In Finnmark, Norway existing nests were moved onto the new artificial structure, but this failed to attract birds away from their nest sites within the town (Wormdal 2020). Nests placed on the structure (real or fake) could also be splattered with white paint to mimic the whitewashing of colonies to act as a visual cue (Coulson 2011).

2.6.5.5 Using real nests will also contribute to chemosensory abilities of seabirds. Friesen *et al.*, (2016) found this to be the least-explored method of sensory-based conservation for seabirds. Despite its lack of application in conservation programmes, many seabirds have an excellent sense of smell. This is especially relevant in tube-nosed Procellariforms, but also in other bird families, for example, kittiwakes have both individual and sex differences in odour (Leclaire *et al.*, 2011).

2.6.5.6 Many taxa communicate and detect cues in multiple sensory modes, i.e. simultaneous acoustic, olfactory and visual signals (Candolin 2003; Hebets and Papaj 2005). This can assist in conservation management as multiple stimuli may provoke a stronger behavioural response than a single sensory mode. For example, in the diurnal Laysan albatross, more individuals landed at sites where both vocalisations and visual stimuli were utilized than sites using visual stimuli alone (Podolsky 1990). Therefore, a combination of calls, models and nests could be incorporated into initial structure design. Testing of any methods incorporated into the monitoring programme would provide valuable empirical evidence of such methods for this species and subsequently inform further artificial nesting structures.

2.7 Identification of coastal areas for deploying artificial nest sites

2.7.1 Area of search

2.7.1.1 As noted previously, the area of search has initially been limited to the English southern North Sea based on the preference for compensation to be located close to the source of impact where possible. For the Hornsea Three project, the SoS stated in paragraph 7.47 of his "Minded to Approve" letter that the coherence of the network of kittiwake Natura 2000 sites can be maintained if a compensatory measure benefits the wider North Sea population of kittiwake generally. Therefore the search area for Hornsea Four ANS sites has been extended to include additional sites along the east coast of England not initially considered as part of Hornsea Three derogation measures. A decision was made by the project to exclude Scottish sites on the basis of lack of support from Scottish government stakeholders.

2.7.1.2 Detailed studies of recruitment would suggest that the number of immigrants recruited into the adult breeding population of an established kittiwake colony probably exceeds the number of philopatric individuals (Coulson 2011). These recruits are coming from a pool of young produced in many colonies within 1,600 km. In other words, the FFC SPA population is not a discrete self-perpetuating unit, but part of the broader UK population together with birds from other European countries i.e. a metapopulation. However, the majority of the 76% birds that are not philopatric choose sites within a neighbouring colony (<100 km) to breed, with a reasonable assumption being that FFC SPA largely contributes to, and draws upon, one multi-colony regional population, the southern North Sea.

2.7.1.3 For the purposes of this study, the southern North Sea regional population is defined as the English North Sea Kittiwake colonies, Northumberland to North Kent. It is within this coastal zone and its adjacent offshore waters that a search of areas to host artificial nesting sites is focused.

2.7.2 Identification of coastal areas

2.7.2.1 From the preceding review of kittiwake colonies, recruitment and population trends, the following criteria are identified that predispose an area to hosting artificial nesting sites that will be occupied by new recruits to the southern North Sea regional population, whilst contributing to an increase of breeding adults:

- Connectivity already exists with the southern North Sea regional population to facilitate initial colonisation by prospective breeders e.g. following trawlers for fish discards into fish quays (e.g. Hartlepool, Tyneside), and power station inflow and outflow seawater pipes (e.g. Sizewell);
- Areas that lie beyond proximity to existing colonies in decline or where nesting failure is generally occurring as this may increases pressure on already limiting factors, that may be driving the decline/failures e.g. food supply;
- A preference for those areas lying within 100 km of existing colonies as the evidence has suggested the majority of 76% birds that are not philopatric choose sites within a neighbouring colony (<100 km);
- Areas lying within mean maximum foraging range of known sandeel habitat areas with potentially high density of non-buried sandeel, as a major prey resource for kittiwake i.e. within 156 km (Woodward *et al.* 2019); and
- Waterfront locations away from urban housing which minimises human interaction and where purpose built artificial nests can overhang water, reducing risk to health, safety, and the environment.

2.7.2.2 The paucity of kittiwake colonies between Yorkshire and Kent reflects the near absence of natural nest sites along this coast i.e. high vertical cliffs. Where colonies have established – on Lowestoft outer harbour and thereafter in 1994 on Sizewell rigs, about 30 km to the south (Suffolk Wildlife Trust 2007) – these lie over 100 km from the nearest colonies in Kent and Yorkshire. Areas beyond the distance most birds would be recruited from their natal colony, < 100 km, should therefore not automatically be discounted for the establishment of new colony through the provisioning of artificial nesting structures.

2.7.2.3 Establishing artificial structures for nesting in two or more different areas would further help ensure success in buffering against localised events e.g. adverse weather conditions, local changes in prey resources due to fisheries or changes in SST, or more unpredictable events like high adult mortality from localised toxin-producing algal blooms (Coulson and Strowger 1999). Furthermore, it would increase the likelihood of connectivity with prospective breeders as over 95% of all recruits select older, established colonies (Coulson 2011). The establishment of multiple new colonies has the potential to also minimise on the lead in time to achieving the size of compensatory population required.

2.7.2.4 Usually, new colonies are created by young birds which have been present at the new site one or more years before the first eggs are laid (Coulson 2011). New colonies typically grow rapidly, and often double in size annually for the first two three years, but thereafter increase at a progressively lower rate. Their initial growth for the first ten years or so is almost entirely dependent on successfully attracting immigrants because potentially philopatric individuals have not reached breeding age for four or five years and in any case the number of young produced in the first few years of the colony is few (see **Section 2.8**).

Table 2.8: Examples of locations with the potential to successfully host the development of artificial nesting structures for kittiwake

Area	Connectivity	Distance to and productivity of neighbouring colonies	Proximity to known sandeel habitat areas	Comments
Seaham Harbour	c.400 pairs breed within harbour and 60 pairs at a natural site on the coast (Orsted 2021)	Several colonies breeding in surrounding area (c. 4000 pairs Durham Bird Club/ INCA/Orsted) up to 20 km distant	<156 km	Potential opportunities to develop within existing harbour walls/ breakwaters
Tees Estuary	430 pairs breed within the estuary, on Conoco Phillips Jetties, Seal Sands (INCA, 2021)	Several colonies (c. 1,295 pairs; Cleveland Bird Report, 2019) breed outside the estuary up to 20 km distant	< 156 km	Potential opportunities to develop on existing industrial wasteland with a water frontage
Hartlepool Headland	422 pairs breed at several sites in Hartlepool (Orsted Surveys 2021)	Several colonies (c. 1,456 pairs; Cleveland Bird Report, 2019) breed nearby, up to 20 km distant	< 156 km	Opportunity to modify the disused (from 2005) 2,000ft long Steetley Pier. Several pairs already breed on site
Lowestoft	768 pairs breed within the town (Orsted surveys 2021)	Sizewell Rigs at 30 km	< 156 km	Enhancement opportunities exist in the harbour
Sizewell Rigs	502 pairs breed on Rig 1 (last available count, 2008)	Lowestoft at 30 km	< 156 km	Enhancement opportunities exist on the rigs

2.7.2.5 Section 2.6 has already identified potential key elements in the physical design of existing artificial nesting structures that may have contributed to their success in becoming a flourishing breeding kittiwake colony. Table 2.8 lists examples of locations that fulfil all or some of the above-mentioned criteria for area selection, within which the opportunity is likely to exist of sites to host the development of artificial nesting structures as per the optimal design.

Conclusion	Context
Suitable coastal locations exist where an artificial colony would have an enhanced chance of success. These areas have potential connectivity to existing colonies where productivity has been good over the last five years, are within range of known prey habitats and show evidence that natural nesting habitat may be limited.	Key areas identified are in the north-east of England – Tees Estuary to south of Seaham and East Anglia – Sizewell to Lowestoft. Provision of structures at multiple sites would maximise the chance of success.

2.8 Growth rate of new colonies

2.8.1.1 Projecting the growth rate of a new artificial site is challenging as data on the colonisation of artificial structures is limited e.g. France and the Tyne (see data in Appendix D: Growth rates of existing artificial nesting sites). In both these situations, birds were actively pushed from original nesting sites on to the new structures so may not be representative of natural colonisation processes.

2.8.1.2 At natural sites, new colonies are usually created by young birds and will typically grow rapidly, and often double in size annually for the first two three years, but thereafter increase at a progressively lower rate. Their initial growth for the first ten years or so is almost entirely dependent on successfully attracting immigrants because potentially philopatric individuals have not reached breeding age for four or five years and in any case the number of young produced in the first few years of the colony is few. Figure 2.6 shows growth rates observed at three natural colonies in North East England (Coulson 2011). Coquet Island has been monitored from the first initial breeding in 1991, so is likely to show the best scenario for establishment of a new colony at a new site where birds had not previously bred nearby. However, Coquet was colonised during a period of population expansion of kittiwakes across the UK in general, so these rates may be opportunistic as recent UK trends show a decrease in kittiwake numbers (SMP 2019).

2.8.1.3 Kidlaw *et al.* (2005) described the growth of colonies in Alaska and record that they are typically founded by variable numbers of pioneers (23 pairs on average) and exhibit rapid growth in the first four years. Thereafter, growth declined to 10%–20% per annum and exhibited lower interannual variability.

2.8.1.4 Coulson (2011) noted that new colonies are usually formed by between 3 and 20 nesting pairs. An infrequent exception to this pattern occurs when an existing colony becomes unsuitable (e.g. Tyne) and relocation occurs.

2.8.1.5 The way in which individuals establish and introduce themselves to the colony explains some of these patterns. New recruits prefer occupancy in the centre of a colony. After the first few years, the availability of breeding space in the centre of the colony is primarily controlled by the death of previous site owners. New recruits are increasingly forced to find sites closer to the edge of the colony where there is more space (although it is assumed birds will seek to nest within 3-5m of existing sites). However, as the colony grows in size its edge (as a proportion of the whole colony) and the space within it declines, slowing the rate of growth.

2.8.1.6 It should be expected, therefore, that newly established artificial nesting sites will grow rapidly in the first 3-5 years, followed by growth at a slower rate thereafter. In addition, young prospecting breeders often visit colonies and loaf around breeding sites for 1-2 years before breeding attempts occur (Coulson 2011). Birds require social stimulation of other breeding pairs to initiate breeding activities (Coulson 2011), The Tyne kittiwake tower initially used decoy birds to attract recruits to the Tyne tower (Turner 2010), so this may be a possible way to encourage new breeders in more quickly.

2.8.1.7 Colony success and growth rates are also dependent on availability of recruits, food resources, survival rates. The size of the pool of recruits available in the North Sea is unknown and is difficult to ascertain (Black & Ruffino 2020). The availability of food resources in an area can be implied by proxy by choosing a location near an existing colony with good productivity rates.

Conclusion	Context
Projecting the growth rate of a new artificial kittiwake colony is challenging due to data on colonisation of new artificial nesting structures being limited.	A newly established artificial nesting sites is likely to grow rapidly in the first 3-5 years, followed by growth at a slower rate thereafter.

2.9 Artificial nest sites as a conservation measure

2.9.1.1 Where competition is intense for limited nest sites within established colonies, potential recruits may make use of lower-quality nest sites or, defer breeding and join a pool of "floaters" rather than colonize unoccupied habitat that is often available nearby. The size of this pool of "floaters" has been acknowledged by OWSMRF to be a gap in current knowledge (Black & Ruffino 2020). However, digital aerial surveys for the Hornsea Zone plus a 10km radius found large numbers of immature birds in the area during the breeding season (Webb *et al.*, 2017).

2.9.1.2 It is known that poorer food conditions decrease productivity, reduce growth rates of chicks, and affect age-at-recruitment of the same cohort (Vincenzi & Mangel 2014). Food supplementation may have long-term positive effects on a colony (Gill and Hatch 2002) but comes with logistical and financial constraints.

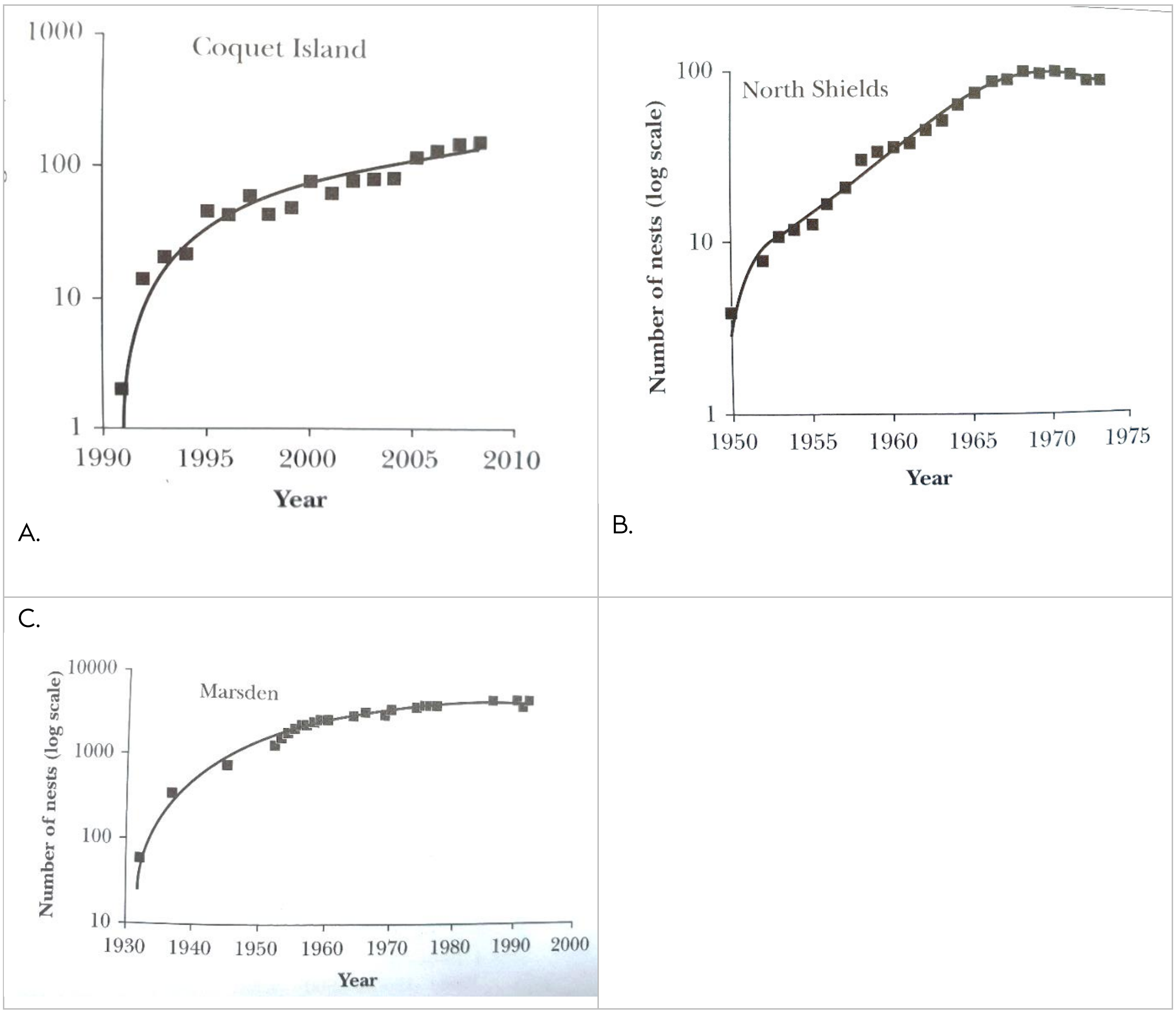


Figure 2.6: Population trajectories for three colonies during a period of growth. A. Coquet Island, B. North Shields, C. Marsden Rocks. Adapted from Coulson (2011)

2.9.1.3 The success of this measure is dependent on the availability of nest sites being a limiting factor for kittiwake populations. For the majority of areas in the North Sea, this does not appear to be the case (McArthur Green 2013), however, evidence exists that this measure would be a feasible compensation measure along the East Anglia region of the southern North Sea to recruit into the wider Eastern Atlantic population (McArthur Green 2013, McArthur Green 2020). There is strong evidence that kittiwakes in the southern North Sea are limited by nesting habitat (Coulson 2011), as there is a lack of suitable cliffs along much of the south-eastern coast of England.

2.9.1.4 "Seabird 2000 (Mitchell *et al.* 2004) found no kittiwakes breeding in Norfolk or Essex, and only 369 pairs in Suffolk (those birds all nesting on man-made artificial structures, and not in natural habitat). In contrast, the cliffs of Flamborough and Filey Coast in Humberside hold over 40,000 pairs of kittiwakes, the largest colony of the species in the UK (Mitchell *et al.* 2004). Exceptionally large colonies occur only where there is little or no suitable nesting habitat elsewhere within the foraging range of seabirds from that colony (Furness and Birkhead 1984). This implies that provision of artificial nest sites in south-east England would be likely to attract kittiwakes to nest at sites where competition for resources would be less than at the exceptionally large colony of Flamborough and Filey Coast SPA." – McArthur Green (2020). In combination, these observations support an opportunity to increase kittiwake productivity in East Anglia by provisioning of desirable residences.

2.9.1.5 By providing additional nesting space within a productive location there is the potential that this will attract birds from this pool that may have otherwise nested elsewhere at colonies experiencing lower productivity trends. However, with our current state of knowledge on the species ecology proving that this is the case is empirically challenging. Studying the colonisation of a new structure could help contribute to this knowledge base.

2.9.1.6 Some additional points to consider when thinking about the best sites for artificial nesting structures for kittiwakes are:

- Proximity to nesting material may be especially important if artificial structures were located offshore;
- Initial colonisation of sites may take time and younger birds tend to have lower breeding success (Coulson 2011). Therefore, it may take a few years before colony productivity would reach a productivity threshold where birds are contribution to the wider regional population. However, as a colony grows it is more likely to attract new recruits;
- Little is known about prospecting movements of juvenile kittiwakes i.e. if they would be willing to travel to areas where no historic colonies exist (e.g. low-lying area like the Norfolk coast). In recent years birds have attempted to nest on the ground at Minsmere in Suffolk (indicating a lack of alternative nesting sites), however birds nesting at Sizewell rigs use this site to gather nesting material so the site may have been familiar to the birds; and
- Potential for additionality will be important to consider in choosing sites that will allow additional birds to recruit into the breeding population that would otherwise be

limited by the lack of natural/other nesting opportunities. Therefore an assessment of the limitation of alternative natural or artificial nesting opportunities within each potential location.

Conclusion	Context
As a colony grows it will become more attractive to first time breeders, 95% of new recruits select older established colonies (Coulson 2011).	In order to establish a new site there will be a higher chance of success if breeding birds are already present nearby.

2.10 Monitoring the effectiveness of the compensatory measures

2.10.1.1 The success in deployment of artificial nest sites would need to be monitored through observations of the numbers of breeding birds and their breeding success. A purpose-built structure or suitably modified pre-existing building, for the study of the breeding kittiwake would be preferable to ease the accessibility of the colony for monitoring.

2.10.2 Empirical testing

2.10.2.1 The deployment of artificial nest sites presents the opportunity to conduct empirical testing of various design feature with respect to the colonisation and productivity of the colony. For example, the aspect, width, and height of nesting ledges. Such a study together with those described for diet and adult survival, are examples of the research opportunities that deployment of artificial nest sites can offer.

2.10.3 Diet and adult survival

2.10.3.1 A purpose-built structure or suitably modified pre-existing building, for the study of the breeding kittiwake, should be considered that enables easy access to the nest, adults, and chicks for ringing studies over the long term. This would enable the monitoring of survival/return rates to be undertaken, enabling a comparison with other colonies, including FFC SPA, which contribute to the Retrap Adult Survival (RAS) study on kittiwake coordinated by the British Trust for Ornithology (BTO). The methodology of the RAS study entails ringing adult birds with uniquely engraved colour-rings so that each bird can be identified in the field in future years. The BTO uses re-sightings of colour-marked individuals and captures of adult birds to calculate what proportion survives each year. The aim of a RAS study is to capture or, for birds colour-ringed from previous years, re-sight birds breeding within a defined area of the colony each year.

2.10.3.2 Access to adults and chicks will also enable monitoring of their diet, to look at the prey species available to kittiwakes at these new (or previously unstudied) locations.

2.10.4 Additionality

2.10.4.1 The collection of comparative breeding success data from ANS and local / wider regional sites will be crucial in establishing whether birds nesting on an ANS are producing additional numbers to those they may have produced if they had recruited into a site elsewhere. Differences in productivity rates (i.e. number of chicks produced per pair) would be monitored and assessed annually against local and national trends.

2.10.5 Colony Interchange

2.10.5.1 Increasing the number of kittiwakes that could be uniquely identified i.e. ringing birds with uniquely identifiable rings is currently the only feasible way to monitor interchange of birds between colonies. Technologies may be developed in the future to facilitate more detailed studies in this area and adaptive management measures should be flexible and able to incorporate these opportunities as they arise. A ringing programme should be adopted at the ANS and at colonies within potential colonisation range i.e. 100 km where catching opportunities would be feasible.

2.11 Roadmap for deployment of artificial nests: Pre- & post- construction

2.11.1.1 The following process is proposed to maximise success of the proposed mitigation measure:

2.11.1.2 Following the roadmap presented in **Figure 2.7**, that there is a degree of management feedback required at certain stages to ensure objectives are met. Issues which may arise post construction and potential solutions are discussed in detail below. Adaptive management options will be linked to the monitoring plan and are expected to be developed in consultation with a Hornsea Four Offshore Ornithology Engagement Group (OOEG). Post-construction monitoring will identify required maintenance and potential additional works to be undertaken at the structure, following the breeding season.

2.11.2 Adaptive Management

2.11.2.1 Adaptive management is an iterative, post-consent process which combines management measures and subsequent monitoring with the aim of improving effectiveness whilst also updating knowledge and improving decision making over time. Adaptive management will be an important component of the compensation measure and used as a method to address unforeseen issues or deviations from expected time scales (i.e. colonisation rate of structure). Adaptive management measures are therefore designed to support the compensation measure once functioning as a way of furthering the success and supporting resilience of the measure.

2.11.2.2 Any adaptive measures will be explored with relevant stakeholders as part of the OOEG to identify an initial list of potential approaches within identified parameters. At this early stage, potential adaptive management options have been identified for issues which could theoretically arise. Further detail on each adaptive management option is presented below.

2.11.2.3 As detailed in the preceding sections of this report, kittiwake populations show a varying degree of interannual variability. It is therefore important to note at this stage that monitoring, and any subsequent adaptive management measures, will require that population variability is an integral consideration before action is taken.

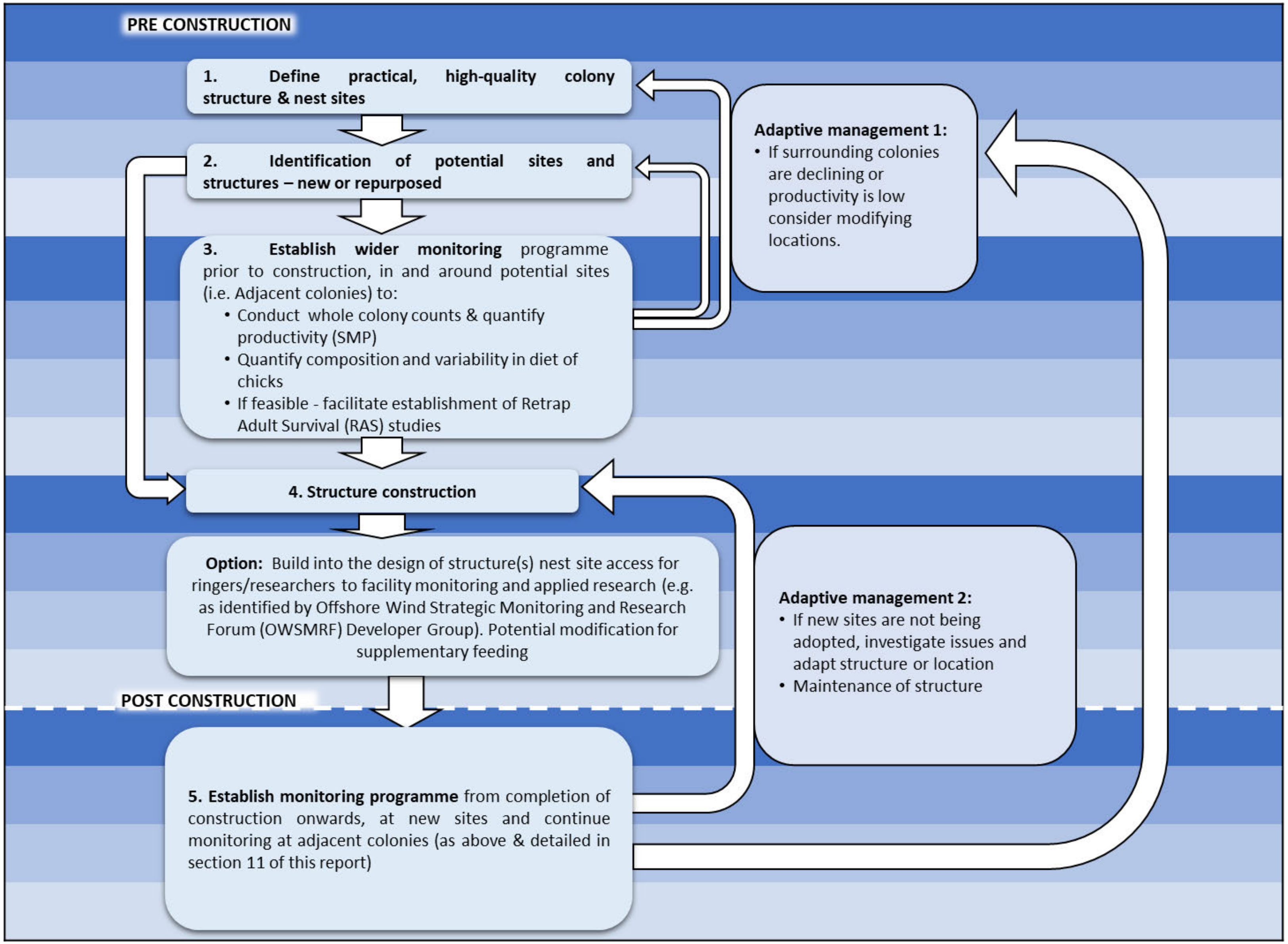


Figure 2.7: Flow chart for roadmap to implement provision of artificial nests for kittiwake.

2.11.2.4 Multiple adaptive management measures will be explored prior to the construction of the artificial structure as it is important to consider the differences between intelligent structure design, and maintenance activity, and adaptive management.

2.11.3 Supplementary feeding

2.11.3.1 The process to select the site for the artificial structure put great weight on locations where productivity is favourable, and the population is expanding. This provides confidence that prey availability is unlikely to be an issue in the short- to medium-term. Different regions were chosen for platform locations to mitigate against regional changes in forage fish populations. Monitoring of kittiwake diet at the platforms will be carried out to understand the site-specific importance of local prey and will be compared with adjacent natural colonies.

2.11.3.2 One study (Gill and Hatch 2002) found that providing supplementary food at the nest, increased fledging success in kittiwake at the colony. This study provides both robust and compelling species-specific evidence that supplementary feeding as an adaptive management measure would likely increase the productivity of kittiwake, if deemed necessary. While this is a key finding, further studies at the colony highlighted a number of other benefits learned from supplementary feeding. For example, Vincenzi *et al.*, (2013) found that fed chicks grew faster than unfed chicks and that birds were more likely to reproduce at younger ages when recruiting into fed nests. The same study also found increased chick growth when parents were fed at the nest (Gill, Hatch and Lanctot 2002). Additionally, White *et al.*, (2010) found that the sustained increase in food supplies as a result of supplementary feeding of kittiwake chicks also reduced brood mate aggression at the colony (a factor which may influence productivity).

2.11.3.3 Supplementary feeding has been used with other seabird species with compelling evidence of success. Although there is only limited evidence for supplementary feeding in kittiwake, it remains a potential adaptive management measure that can be empirically tested in the UK with the likelihood of increasing fledgling success. However, there is no evidence on the effectiveness of providing supplementary food to increase the likelihood of colonisation of a site or encouraging recruitment. As mentioned above, exact methods will be discussed with the OOEG.

2.11.4 Attachment of 'bolt on' to provide additional nesting space

2.11.4.1 The initial design of the artificial kittiwake nesting structure will aim to provide nesting capacity for the predicted impact for Hornsea Four and the relevant breeding population required to provide a comparable number of young that would survive to adulthood (presented in **B2.6 RP Volume B2 Chapter 6 Compensation measures for FFC SPA Overview: Table 2**). This size structure will be constructed at two locations: a North East Search Zone and an East Anglia Search Zone.

2.11.4.2 It is likely that the initial structures will include nesting space which surpasses this amount of potential breeding pairs. However, if monitoring of breeding pairs at the structure suggests that additional nesting space is required to ensure the growth of the colony, a 'bolt on' of additional nesting space in the form of an extension to the structure can be provided. This will likely be determined by the initial design of the structure (i.e. potential to be unfeasible due to landowner or planning constraints).

2.11.4.3 This option at the colony would be installed during the non-breeding season when birds are absent and therefore cannot be disturbed. The trigger point for application would be influenced by the monitoring programme which will be set out in full within a Kittiwake Implementation and Monitoring Plan.

2.11.5 Relocation of structure

2.11.5.1 The relocation of an artificial nesting structure is unlikely to be required due to the diligent design and site selection process which will be undertaken prior to construction. However, unforeseen issues may result in a structure being less favourable, for example if there is persistent unauthorised access. If this is determined by the monitoring programme, consideration will be given, in-line with discussions with the OOEG and relevant land acquisition consultation, to the relocation of the structure.

2.11.6 Adaptation of Structure

2.11.6.1 At this stage of development, the design of the artificial nesting structures remains unconstrained. This report provides a compelling account of previous and current kittiwake nesting towers from across the species breeding range. This is likely to result in the initial structure factoring in many of the key design features required for a successful structure. However, monitoring may indicate that small adaptations are required to improve sustainability of the colony for the following breeding season. For example, this may include weather proofing to reduce the exposure of nesting birds to the elements which was not deemed necessary during the design stage. This was found to be the cause of colonisation issues of artificial shelves at a site in France where sun exposure of the south-facing ledges added to a harbour building were less favourable to prospecting birds (see **Table 2.3**, J.M. Sauvage pers. comm.).

2.11.7 Predator Deterrents

2.11.7.1 Initial nesting structure design will incorporate features aimed at preventing avian and/or mammalian predation. However, it is acknowledged that the approach to predator deterrents may need to be adapted if initial process is unsuccessful or predators are able to surpass initial deterrents. If this is found to be the case as a result of site monitoring, solutions will be discussed within the OOEG on how to resolve the issue, with the aim that adaptations could be made to the structure during the non-breeding season when birds are absent.

2.11.8 Provision of Nesting Material

2.11.8.1 Kittiwake nests are bonded to the 'cliff' surface by the mud used by the birds during nest construction. Kittiwake usually collect mud from a localised point along sea cliffs, and often after periods of rain when the mud is easier for them to collect in their bills

(Coulson, 2011). Birds then collect vegetation such as seaweed and grass which is then compacted into the mud foundation to form a shallow cup. At natural colonies, this material is collected at the top and base of cliffs and usually within 2 km of the colony, although some records document further distances (Coulson, 2011). In an urban setting such material may be limited and may therefore require extended journeys by the birds in order to collect.

2.11.8.2 At an artificial colony, these materials could be provided in proximity to the structure to limit the need for birds to search and travel to collect them during the nest building stage. The provision of nesting material has been used by the artificial nesting structures built in Norway to compensate for the lack of suitable nesting material in Tromsø. Provision of materials such as wet mud (in the form of manure) and straw was spread in a cliff top field in proximity to the Marsden kittiwake colony during April (when most nest building occurs) which reportedly resulted in almost every nest having visual evidence of using the provided material (Coulson, 2011). Therefore, nesting material could be provided within 2 km of the artificial nesting structure. This would be repeated each year to allow for birds to make new nests, or repairs to old nests from the previous breeding season. This option may be incorporated into project design if the chosen locations for artificial nesting structures are not deemed to be in proximity to nesting materials. Provision of a small pond/scrape where birds could collect mud in the vicinity of the structure could be an option to facilitate nest building.

2.11.9 Maintenance

2.11.9.1 It is worth noting at this stage that ad-hoc maintenance, not linked to adaptive management, to the structure will also be highlighted by the monitoring plan. This will allow any remedial works or repairs to be conducted during the non-breeding season when breeding birds are not present at the structure.

2.11.9.2 While maintenance work will be informed by the monitoring plan, a number of potential works which may theoretically arise are listed below:

- Removal of kittiwake guano from structure;
- Remedial works to structure (i.e. storm damage to nesting ledges);
- Ensuring structure is structurally sound;
- Changing batteries used for speakers playing kittiwake calls; and
- Removal of litter, graffiti or any objects deemed hazardous to kittiwakes.

2.11.10 Potential to Contribute to OWSMRF Knowledge Gaps

2.11.10.1 The Offshore Wind Strategic Monitoring Research Forum (OWSMRF) is an industry-led collaborative forum that aims to better understand the impact of large-scale offshore wind development on marine birds. It has identified critical gaps in our understanding and identified research opportunities to fill these gaps. Many of these research opportunities require a hands-on approach at seabird breeding colonies i.e. catching and handling birds.

2.11.10.2 Kittiwakes do not allow close approach to the nest by humans to enable adult birds to be captured by hand. Where within reach and individual birds allow, breeding adults can be lifted off the nest safely using a noose on the end of a 5-metre pole by an appropriately trained and licensed seabird ringer. However, a design option which allows hidden access to birds (e.g. access to birds through hatches in the structure) (see **Figure 2.7**) would be beneficial to RAS studies Horswill *et al.* (2018) recommend that for RAS studies to be successful, studies should have a ten-year trajectory and a recapture rate of 0.6, and should aim to mark at least 200 new adults per year. A well-designed and monitored artificial nest site has potential to contribute to research opportunities identified for OWSMRF (Ruffino *et al.* 2020). The research will be focussed at the artificial nest structure and adjacent colonies nearby specifically:

- RO3.1c - Undertake targeted empirical data collection as informed by the sensitivity analyses (RO3.1b);
- RO3.3c - Deploying strategic adult kittiwake mark-recapture at multiple colonies, and analyses of re-sighting data (RAS studies);
- RO3.3d - Deploying strategic chick mark-recapture at multiple colonies, and analyses of re-sighting data; and
- RO3.9 - Regional comparison of kittiwake diets during the breeding season: field studies[2]

2.12 Why it delivers on compensation for the Adverse Effect on Site Integrity

2.12.1.1 The magnitude of the potential impact that should be offset is presented in **B2.6 RP Volume B2 Chapter 6 Compensation measures for FFC SPA Overview Table 2**. Hornsea Four firmly maintains the position that in respect of the designated sites, that there would be no AEoI as a result of the project alone and in-combination with other plans and projects and an AEoI can be ruled out beyond reasonable scientific doubt. Potential 'without prejudice' compensation measures have been identified and could be developed should the Secretary of State conclude AEoI on any of the qualifying features.

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

a) Create artificial nesting sites that would be used by breeding kittiwakes; and
b) Specify the design, location, and scale of those sites sufficient to offset the predicted impact.

2.12.1.3 On the basis of this review, it is considered that it is feasible to provide artificial nesting sites at a coastal location(s) to provide additional breeding habitat for kittiwakes. There are successful examples of sites designed specifically for this purpose as well as many other sites where kittiwakes have opportunistically made use of man-made structures to successfully breed. These sites typically support self-sustaining breeding populations

[2] This is distinct from the work proposed in the Prey Resource Plan as it is intended to inform adaptive management at the nest sites, as opposed to building the East Coast evidence base to inform international sustainable fisheries advice by relevant authorities.

within a relatively short period of time.

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

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

2.12.1.6 On the basis of this review it is considered that the creation of artificial nesting structures that can support the required pairs (dependent upon the position taken by the SoS) of nesting kittiwakes will produce sufficient young that will in turn mature and disperse to provide additional breeding adult birds in the population to fully offset the potential impact of collision mortality of kittiwakes at Hornsea Four. This approach will be sustainable for at least the lifetime of Hornsea Four offshore wind farm and hence the period within which collision mortality would occur.

2.13 Conclusion (kittiwake)

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

2.13.1.2 The predicted impact for Hornsea Four and the relevant breeding population required to provide a comparable number of young that would survive to adulthood to offset the impact of Hornsea Four is presented in **B2.6 RP Volume B2 Chapter 6 Compensation measures for FFC SPA Overview Table 2**. There are examples of artificial nest sites supporting breeding populations of this size.

2.13.1.3 There are a number of suitable locations on the coast of the southern North Sea (East Anglia and the North East) where artificial nest sites could be installed and there are a number of other site-specific factors (including design, orientation and accessibility) that should be taken into account when a site is selected.

3 Northern Gannet

3.1 Northern gannet threats and national population trends

3.1.1.1 Northern gannet (hereafter 'gannet') populations in the UK are increasing at a rate of around 2% per annum, with an increase of 34% between census in 2003-04 and colonies surveyed in 2013-15 (JNCC 2020). Due to the growing population trajectory, the species faces few threats which are likely to cause population level declines. However, UK gannet colonies show classic density dependence, where competition for resources (likely either prey or nesting space; Lewis *et al.,* 2001) is more intense at larger colonies, limiting their population growth (i.e. approaching carrying capacity; **Figure 3.1**; Wanless *et al.,* 2005). Construction of artificial nesting structures offers a potential avenue to maintain national gannet population growth by establishing attractive, low-competition colonies while compensating for wind farm mortality.

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

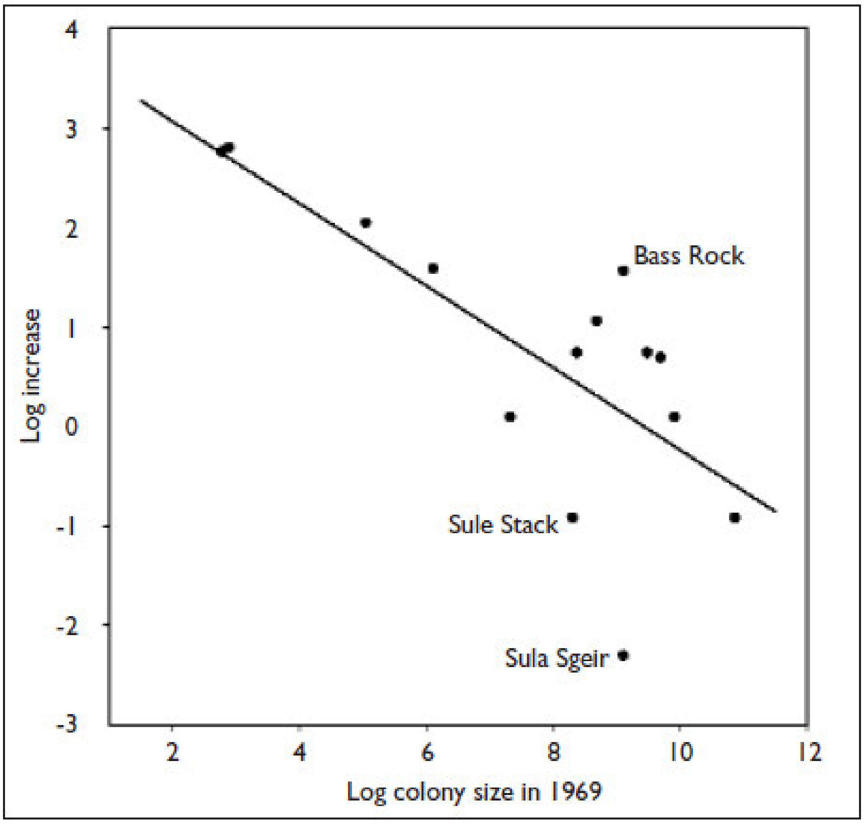


Figure 3.1 Log-log plot of rates of change in numbers of Northern Gannet at British and Irish colonies between 1969 and 2004 against colony size in 1969. The line represents density dependence, where larger colonies (in 1969) have lower growth. Figure from Wanless *et al.* (2005)

3.2 Evidence of gannet colonising artificial structures

3.2.1.1 The literature review revealed numerous studies of gannet nesting on artificial (man-made) structures (**Table 3.1**). Although smaller and rarer compared to natural gannet colonies, the examples presented here provide compelling evidence that gannet are not discouraged from establishing and maintaining colonies on artificial structures.

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

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

3.2.1.4 Better studied examples come from Australasian Gannet colonisation of several artificial structures in Port Phillip Bay, Victoria, Australia. The Wedge Light colony was established on a flat wooden landing platform 3 km offshore, and grown from its inception in 1966 (at least three nests) to up to 50 nests in the 1988–92 period. Removal of a central hut increased the potential breeding area, and in 1997 the platform held 58 nests, including two on structural cross beams under the platform (Norman *et al.,* 1998). The Pope's Eye colony started on a similar flat wooden landing platform approximately 3 km offshore. By 1985 there were 25 nests, which were in part established by birds from nearby Wedge Light, and in 1988 there were 46 active nests. After construction of a new platform and walkway the colony expanded to 120 nests by 1992 and continued to increase onto surrounding artificial rocks up to 140 nests in 1994 (Norman *et al.*, 1998). A further four colonies, all on artificial structures, are known to have established since Wedge Light and Pope's Eye in Port Phillip Bay (**Figure 3.2**). These take the form of channel navigation markers and an artificial concrete caisson, providing platform areas of between four and 45 m2 which are used for nesting (Norman 2001).

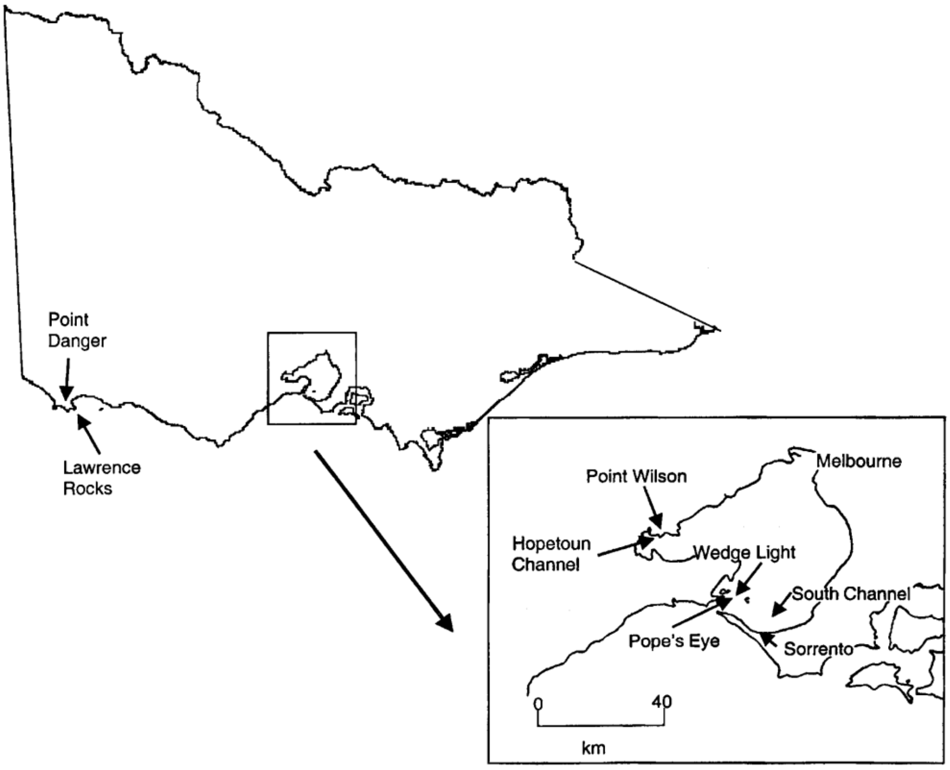


Figure 3.2 Map of Victoria, Australia showing location of established Lawrence Rocks Australasian Gannet colony (2,463 pairs) and inset showing colonies established on artificial structures in Port Phillip Bay. Map from Norman (2001).

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

3.2.1.6 The colonisation of French and Italian harbours by Northern gannet and Port Phillip Bay by Australasian Gannet demonstrate an apparent preference for artificial structures given the availability of apparently suitable natural sites to colonise. Giagnoni *et al.* (2015) notes "This choice of nesting sites probably did not depend on unavailability of natural habitat in the area; in fact the terraced cliffs of Palmaria Island and the promontory of Porto Venere appeared suitable". At Carry-le-Rouet Northern Gannet were encouraged away from the jetties chosen for nesting in the harbour (using wooden silhouette decoys) to a neighbouring natural site but chose to remain. The Australasian Gannet colonisation of artificial structures in Port Phillip Bay was fuelled through immigration from birds from the nearest large colony of Lawrence Rocks (2,463 pairs; Norman 2001). However, there is approximately 300 kilometres of seemingly suitable nesting coastline (headlands and islands) between Lawrence Rocks and Port Phillip Bay (**Figure 3.2**), why a nearer, natural site was not colonised in preference to artificial structures at the gateway to Melbourne harbour is unknown. Immigration from Lawrence Rocks also likely established the Australasian Gannet colony on the ex-lighthouse support structure at Margret Brock Reef, approximately 260 km to the west, again, seemingly in preference to suitable natural habitat.

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

Table 3.1: Evidence of gannet colonising artificial structures

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

Figure 3.3 Australasian Gannet breeding at Margret Brock Reef, South Australia. Image from Eremorphila (2014)

Figure 3.4 Australasian Gannet breeding at Pope's Eye, Victoria, Australia. Image from The Nature Conservancy Australia (2021)

Figure 3.5 Northern Gannet breeding at Sausset-Les-Pins, Provence, France in 2004. Image from Renaud *et al.* (2006)

Figure 3.6 Northern Gannet breeding at Carry-le-Rouet, Provence, France in 2009. Image from Deideri *et al.* (2014)

Figure 3.7 Northern Gannet breeding at Carry-le-Rouet, Provence, France in 2012. Image from Deideri *et al.* (2014)

Figure 3.8 Northern Gannet breeding at Porto Venere, Italy. Image from Giagnoni *et al.* (2015)

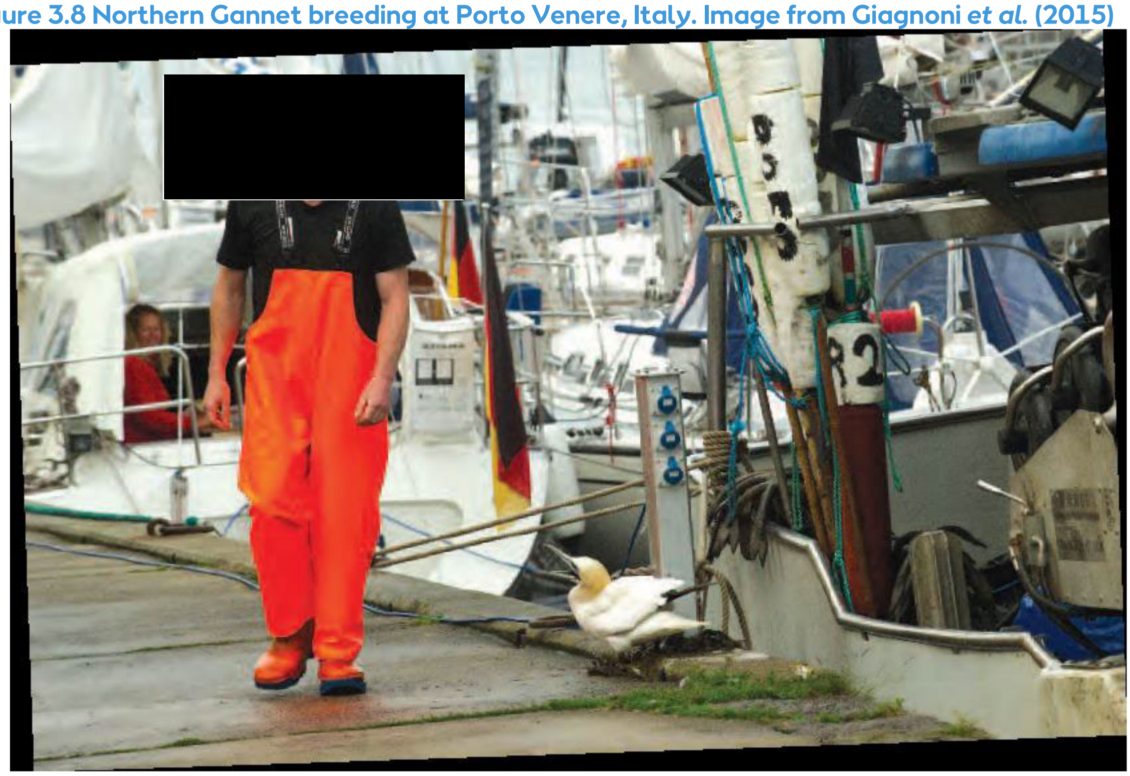


Figure 3.9 Northern Gannet breeding Christiansø, Denmark in 2013. Image from Lyngs (2015)

Figure 3.10 Northern Gannet breeding at Seaford, East Sussex in 2000. Image from Palmer (2001)

3.3 Feasibility of establishing new gannet colonies

3.3.1 Overspill, colonisation, and population growth

3.3.1.1 The pace of gannet colonisation (of a new colony on natural habitat or an artificial structure) is largely influenced by the size and vicinity of established colonies. Population growth can be rapid at a new colony when a large population exists locally to fuel immigration. Northern Gannets colonised Lambay Island in Ireland in 2006 and by 2013 there were 728 AONs, similarly Northern Gannets colonised Sule Skerry in Scotland in 2003 and by 2018 there were 4,515 apparently occupied sites (Harris *et al.*, 2019). In both cases a large established gannetry occurred nearby (Lambay Island 10 km from Irelands' Eye; Sule Skerry 8 km from Sule Stack) which 'seeded' the new colony and fuelled its early growth (confirmed by ringing recoveries; Harris *et al.*, 2019). By contrast the Bempton colony established in England is thought almost certain to have been founded by birds from Bass Rock (Nelson 1978). Despite the large size of the Bass Rock colony, it is located approximately 270 km from Bempton and initial stages of population growth were slow: one or two pairs were recorded at Bempton from the 1920s through to 1951, which gradually increased to around 12 pairs in 1963, and up to 21 apparently occupied sites in 1969. By 1977, 169 nesting pairs were recorded, and Bempton has continued rapid growth to the present day (Nelson 1978). Nelson (1978) suggests that new colonies need to reach a critical mass of breeding birds, at which point behavioural and social stimuli increase the "tempo of activity" in the colony (increased breeding success, earlier colony return, laying and fledging, and greater numbers of immature birds). This is important as new gannet colonies are sustained by immigration rather than their own reproductive output until they reach about 620 nests (Moss *et al.*, 2002), and more attractive new colonies with higher immigration will reach a self-sustaining population faster (Table 3.2).

Table 3.2 Years between colonisation and reaching a population of 620 pairs, nests, or sites by Northern Gannet colonies in the Northeast Atlantic. + indicates still to reach this size. Table from Harris *et al.* (2019)

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

3.3.2 Social attraction to increase rate of colonisation

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

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

3.4 Conclusion (Northern Gannet)

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

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

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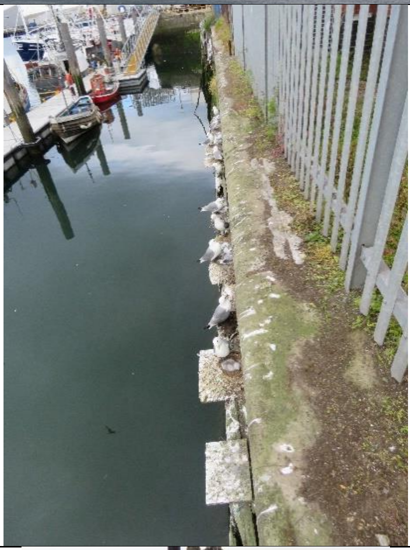
Appendix A Urban nesting site examples

Appendix A

Urban nesting site examples

Hartlepool Headland – Photo credit Chris Brown	
	
	
	

Lowestoft photo credit Mike Swindells	
	
	

Appendix B Successful and unsuccessful artificial nesting sites

Appendix B

Successful and Unsuccessful Artificial nesting sites

i. Successful North Sea sites:

Tyne Kittiwake Tower

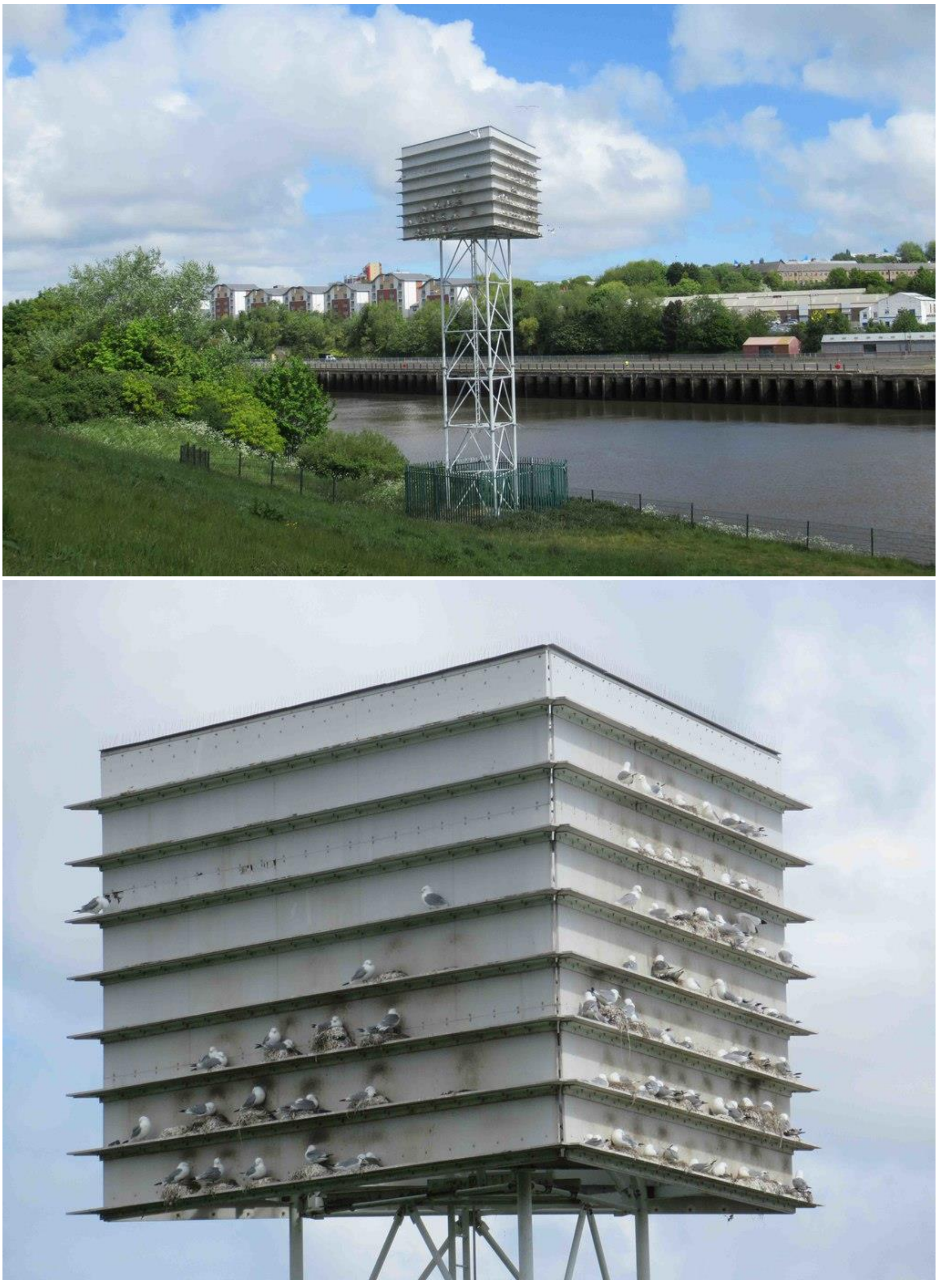


Figure 0.1 Tyne Kittiwake tower. Photos © Les Hull geograph.co.uk

Figure 0.2 Tyne Kittiwake colonies in relation to artificial nest site provision

Lowestoft Wall

Figure 0.3. Lowestoft wall (post breeding season). Photo E Morgan.

Figure 0.4. The end of the Lowestoft Wall. Photo credit M. Swindells.

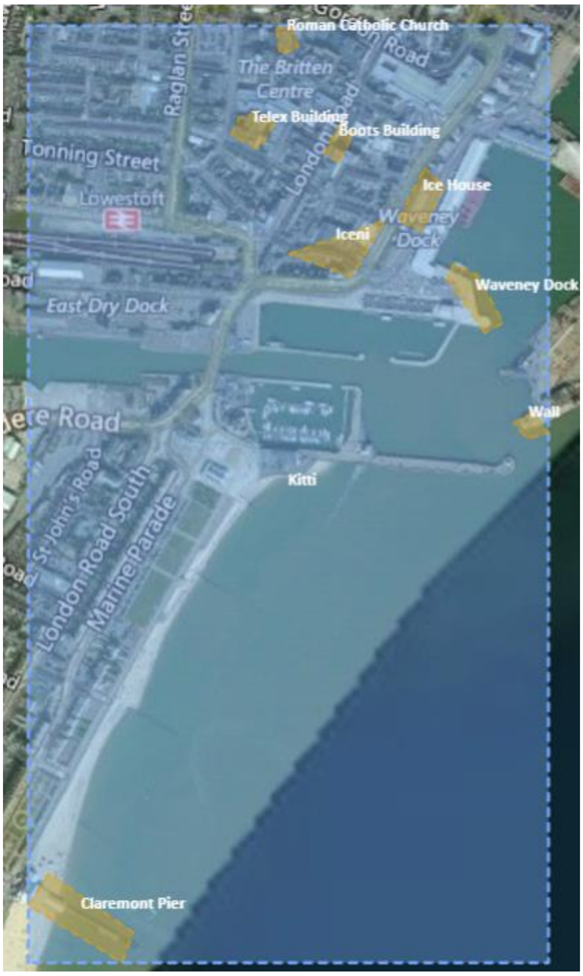


Figure 0.5. Location of Kittiwake sites in Lowestoft. Image credit M. Swindells

Boulogne-Sur-Mer wall

Figure 0.6. Boulogne-Sur Mer wall. Photo copyright J. M. Sauvage.

a. Mumbles Pier

Figure 0.7. Mumbles lifeboat station and kittiwake shelves close up. Photo © Nilfanion Wikimedia UK.

ii. Unsuccessful sites

a. South Shields Tower (right tower in Figure 0.9)

Figure 0.8 Kittiwake tower designs, from right to left: Tyne/Gateshead, Boulogne, South Shields. Photo copyright J-M Sauvage.

Figure 0.9. Location of South Shields Tower, a) in relation to wider Tyne colonies, and b) Fine scale location showing surrounding environment.

Boulogne Tower(s)

Figure 0.10Boulogne kittiwake tower on old ferry terminal. Photo copyright J-M Sauvage.

Tromso Kittiwake Hotel

Alternativer

Forskerne har nå bygd alternative reirplasser på en av moloene i sentrum, for på den måten se om de klarer å lokke måkene vekk fra for eksempel Fylkesbygget, NAV-bygget og Mack Ølbryggeri sine gamle fabrikklokaler. Samtidig ivaretar Sanne Bech Holmgård ,ved NIKU – Norsk institutt for kulturminneforsknings avdeling på Framsenteret, den samfunnsfaglige delen i prosjektet; hun intervjuer folk flest om deres forhold til måker.

På sørjeteen (Folk i Tromsø kaller molo for jete) har forskerne bygd alternative reirplasser. Nå gjenstår det å se om krykkja flytter inn. Foto: Tone Kristin Reiertsen.

Figure 0.11.Image of Tromso kittiwake hotel image from news article available @ https://framsenteret.no/nyheter/2020/03/27/de-skriker-driter-og-okkuperer-hus-hvorfor/

Finnmark kittiwake hotel: Image available via hyperlink below.

Figure 0.12. An image of Finnmark kittiwake hotel can be found online @ https://www.nrk.no/tromsogfinnmark/fredet-fugl-vil-ikke-flytte-inn-pa-krykkjehotell-i-berlevag-1.15040559

Appendix C List for site selection criteria

Appendix C

List for site selection criteria

Kittiwake potential artificial nest site location considerations

1.1 Broad scale:

- Coastal location
- Natural nesting sites are limited
- Connectivity for initial colonisation possible i.e. known regular occurrence of the species within proximity to locality (within < 1 km), whether it be foraging/roosting birds (e.g. following trawlers to fish quay) or breeding at a nearby successful colony
- Within 100 km of existing colonies where populations are stable/increasing
- Food resources available within foraging range of species (successful colonies nearby as proxy)

1.2 Narrow scale:

Ecological

- Breeding kittiwakes already present in area (Smaller populations are prefered to minimise density dependent competition i.e. colony specific competition for foraging areas, and ideally higher productivity and population trends).
- Wharf side, or within 100 m
- Lack of natural nesting sites
- Possible to exclude mammalian predators
- Not overly exposed to adverse weather conditions (areas where multiple aspects possible preferred)
- Human disturbance minimal

Logistical

- Space for structure (minimum 12 m x 2 m) and potential for expansion with adaptive management. Or existing structures exist with potential for modification.
- Unrestricted visibility of all potential nesting faces to enable monitoring of individual nests using optics when positioned within 200 m of structure
- Access to structure from the base or above, to enable surveyors to lift adults from nests using a noose and roach pole (6 m), or if the structure was to be a building, nest site access internally via purpose built hatches onto the nests, for the purposes of monitoring
- Reduce likelihood of human conflict i.e. not close to residential/ active business properties.
- Wharf side location with no required use of wharf by vessels / vehicles
- Avoid being in close proximity to existing OWF (i.e. < 5 km) to avoid increasing collision risk

Legal

- Land Ownership / planning rights achievable

Appendix D Growth rates of existing artificial nesting site

Appendix D

Growth rates of existing artificial nesting sites

Figure 0.1: Population trends since year of construction at two artificial sites; Tyne kittiwake tower and Boulogne wall. A. shows number of breeding pairs occupying structures, B. Shows productivity rates. Tyne data (D. Turner available online at https://www.nhsn.ncl.ac.uk/activities/conservation-research/tyne-kittiwakes/tyne-kittiwake-population-data/). Boulogne data courtesy of J-M Sauvage & Eric Petit-Berghe