Hornsea Project Four: Derogation Information

PINS Document Reference: B2.6.2
APFP Regulation: 5(2)(q)

Volume B2, Annex 6.2: Compensation measures for FFC SPA Prey Resource Evidence

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Doc. No: B2.6.2
Version: A

Table of Contents

List of Tables

List of Figures

1 Evidence review

1.1 Introduction

1.1.1.1 This section of the report considers the evidence linking kittiwake, guillemot and razorbill to prey species and identifies gaps in knowledge. This section provides:

- a review of the role of forage fish species in the North Sea;
- an evidence review of kittiwake, guillemot and razorbill feeding strategy;
- an evidence review of prey dynamics, including interactions with commercial fisheries;
- an overview of existing fisheries management; and
- a summary of relevant evidence gaps.

1.2 Forage fish and their predators

1.2.1.1 Forage fish are planktivorous pelagic species (e.g. sandeel, sprat, herring) that are often the pathway for converting plankton production into food available to higher trophic levels (Alder et al. 2008). Sandeel is thought to be the most important prey forage fish in the North Sea (Engelhard et al. 2014). Seabirds are most dependent on forage fish, but other predators also include piscivorous fish and marine mammals. Food web interactions are convoluted and forage fish may compete for food leading to potentially complex interactions. Predators such as kittiwake will compete for forage fish leading to possible effects of one predator on other predators. In particular, the North Sea "offers a wider portfolio of interacting species whose productivity oscillates in response to both the environment and each others' dynamics" (Engelhard et al. 2014).

1.2.1.2 Of the forage fish in the North Sea, all feed on plankton and are short-lived. In general, they mature at 1 or 2 years, and only live for 3 to 5 years (Petitgas, 2010). Due to this high turnover, and with changes in climate and the composition of the North Sea plankton community over the last 100 years, there have been substantial changes in forage fish productivity as a result of changes in prey plankton composition and availability (Beaugrand, 2004; Leterme et al. 2005). With a relative reduction in fishing pressure in the North Sea in recent years, studies have shown that populations of pelagic fish may now be regulated through bottom-up mechanisms (Kenny et al. 2009; Fauchald et al. 2011). There is no consensus on this though, as Mackinson et al. (2009) concluded that populations of both pelagic and demersal fish are still largely shaped by fisheries.

1.2.1.3 Predators that consume forage fish in the North Sea include piscivorous fish, seabirds, and marine mammals and a range of studies have shown that availability of forage fish can exert bottom-up control on these predators (e.g. Cury et al. 2011; Smith et al. 2011). These bottom-up effects are clearest where a predator is a specialist relying on the availability of the particular forage fish. For kittiwake, this may only apply during the breeding season where a shortage of appropriately sized prey may result in breeding failures due to high chick mortality (Wanless et al. 1998; Frederiksen et al. 2004).

1.2.1.4 Sandeel are the most important forage fish species in the North Sea and are a key component in the diet of certain seabirds (including black-legged kittiwake, Sandwich tern, European shag, great skua, Atlantic puffin, common guillemot, razorbill, northern gannet), piscivorous fish (whiting, horse mackerel, grey gurnard, haddock, mackerel), and marine mammals (minke whale, harbour seal, and grey seal) (Harris and Wanless, 1991; BWPi, 2004; Mendel et al. 2008; ICES, 2011; Engelhard et al. 2014). Many of these species are afforded protection under the Habitats or Birds Directives[1] due to their conservation status.

1.2.1.5 Even where a predator's diet does contain a range of prey species, their fitness can be strongly influenced by one prey type if this is of high calorific value (Wanless et al. 2005). Sandeel is one such high energy prey (Hislop et al. 1991) that appears to be linked to improved body condition of fish predators (whiting, grey gurnard, and weever) and grey seals (Engelhard et al. 2013a, b).

1.2.1.6 Although at the scale of the North Sea, no one predator species exerts significant top-down control over forage fish, predators can have substantial impact at local scales. On the Dogger Bank, whiting, grey gurnard, and weever aggregate to high density patches of sandeel, where they can be responsible for >80% of sandeel predation (Engelhard et al. 2008); likewise, whiting and haddock aggregate to high sandeel concentrations off the Scottish coast where they cause significant predation (Temming et al. 2004).

1.2.1.7 The significance of sandeel as a forage fish highlights the need for an ecosystem-based approach to any fisheries management due to complex trophic interactions, demonstrates how sensitive multiple kittiwake prey interactions are to climatic regulation, and highlights the importance of top-down control by a relatively small number of fish species including saithe, whiting, mackerel, and horse mackerel (ICES, 2011). For example, the Shetland sandeel stock is thought to have declined since 2000 due to impacts of predation by an increasing stock of adult herring.

Summary

- Forage fish are planktivorous pelagic species that are often the pathway for converting zooplankton production into food available to higher trophic levels.
- Sandeel is thought to be the most important prey forage fish in the North Sea and is evidently the most important in the diet of seabirds and seals.
- Sandeel are a key component in the diet of seabirds (kittiwake, Sandwich tern, European shag, great skua, Atlantic puffin, common guillemot, razorbill, northern gannet), piscivorous fish (whiting, horse mackerel, grey gurnard, haddock, mackerel), and marine mammals (minke whale, harbour seal, and grey seal). Many of these species are afforded protection under the Habitats or Birds Directives due to their conservation status.
- At local scales, predators can have significant top-down control over forage fish populations.
- With a relative reduction in fishing pressure in the North Sea in recent years, some believe that populations of pelagic fish may now be regulated through bottom-up mechanisms.

[1] https://www.gov.uk/government/publications/protected-marine-species

1.3 Kittiwake feeding strategy

1.3.1.1 The black-legged kittiwake *(Rissa tridactyla)* is a coastal breeding bird found in the North Pacific, North Atlantic and Arctic. It is a small gull species and the only one that is exclusively cliff-nesting, where it forms large, dense colonies on sheer sea cliffs during the summer breeding period (Hatch et al. 2009). Outside of this breeding period, kittiwake are found almost exclusively at sea.

1.3.1.2 Kittiwake are listed as vulnerable on the IUCN red list in recognition of the fact that the species is estimated to have declined globally by around 40% since the 1970s. Climate change and industrial fishing resulting in changes to the main prey species of kittiwake are thought to be the main contributing factors (Frederiksen et al. 2004, Nikolaeva et al. 2006).

1.3.1.3 Kittiwake feed primarily on fish in open water, but over their geographic range their diet is variable and also includes marine invertebrates such as shellfish, squid, and shrimps (del Hoyo et al. 1992-2006). At UK North Sea colonies, kittiwakes feed mainly on sandeels while breeding, although other fish species, such as sprat, and young herring, may replace them in areas where sandeel are uncommon (e.g. Bull et al. 2004; Coulson, 2011; Lauria et al. 2012). Reliance on sandeel varies with region and season and the diet of kittiwake populations from the coast of eastern England can comprise up to 60% sandeel (Furness and Tasker, 2000). FFC SPA, which protects the largest kittiwake colony in the UK, is located in this coastal region. Woodward et al. (2019) list the foraging range of breeding kittiwakes as mean 54.7 km, mean maximum 156 km, maximum 770 km.

1.3.1.4 Sandeel are small eel-like fish that swim in large shoals and are an abundant and important component of food webs in the North Atlantic, linking zooplankton with many fish, seabird and mammal species. Though there are five species of sandeel found in the North Sea, the lesser (or Raitt's) sandeel, *Ammodytes marinus,* is the most abundant and comprises over 90% of sandeel fishery catches. Sandeel bury into sandy sediment overnight and over the winter months (Wright et al. 2000). Whilst overwintering, sandeel emerge between December and February to spawn their demersal eggs onto sand. Larvae then hatch between February and April and are transported by currents for 7-10 weeks (Wright and Bailey, 1996; Régnier et al. 2017). Evidence from tag-recapture studies and research surveys suggests that sandeel do not move far once settled (Kunzlik et al. 1986, Wright et al. 1998). Due to the relatively short period that larvae drift and the dependency of later life-stages on specific areas of sand, several distinct sandeel stocks are now recognised within the North Sea (ICES, 2017) and this is reflected in the regional variation in breeding success of several seabird species (Frederiksen et al. 2005). Older sandeel are active in the water column until early summer, emerging from sand during daylight hours to feed.

1.3.1.5 Atlantic herring (*Clupea harengus*) (hereafter herring) and European sprat (*Sprattus sprattus*) (hereafter sprat) are both species within the family Clupeidae, also including shads and sardines, most of whom are forage fish[2]. All Clupeids feed on plankton, are small, and spawn huge number of eggs. Sprat and herring travel in large schools possibly as a

[2] FAMILY Details for Clupeidae - Herrings, shads, sardines, menhadens (fishbase.de)

mechanism to avoid predation. Both are commercially fished, but herring is regarded in Europe as the most commercially important fishery in history (Went, 1972).

1.3.1.6 The size of sandeel targeted by kittiwake changes throughout the year. Breeding adult kittiwake eat sandeels aged one year and older during April/May but shift to smaller juvenile sandeels for themselves and their young in June/July (Harris and Wanless, 1997, Lewis et al. 2001, Daunt et al. 2008). As kittiwake are obligate sea surface feeders (i.e. they are only able to capture prey within the top metre of the sea surface), sandeels are therefore only available as prey for a relatively short period of time.

1.3.1.7 Kittiwakes may not be able to utilise sandeel fully if there is a mismatch in the timing of sandeel availability and when breeding kittiwakes require peak energy. Sandeel larval growth is highly dependent on matching the onset of spring copepod production. The timing of the spring plankton blooms dictates the timing and emergence of zooplankton and therefore their sandeel predators. Poor synchrony between the peak in larval hatch times and sandeel prey availability can severely impact growth and survivorship leading to low sandeel recruitment (Wright and Bailey, 1996, Régnier et al. 2017), which impacts feeding opportunities for kittiwake at the sea surface (Scott et al. 2006, Carroll et al. 2015). On Foula, Shetland, low availability of young sandeel negatively affected adult kittiwake survival (Oro and Furness, 2002), which indicates that young-of-the-year sandeels may play an important role for adult kittiwakes in replenishing body reserves following breeding while older sandeels tend to remain buried in the sand in early summer and have thus become unavailable to kittiwakes (Ruffino et al. 2020). What this demonstrates is that healthy levels of multiple sandeel year classes are important for kittiwake to survive and breed successfully.

1.3.1.8 Climate change is also having an influence on sandeel within the North Sea. Warmer seas delay the sandeel spawning time and are expected to also delay hatch times (Wright et al. 2017a). At the same time, warming also leads to an earlier onset of spring plankton blooms. This can lead to a mismatch between peak sandeel hatch times and prey availability and will adversely affect sandeel growth and survivorship leading to low recruitment (Wright & Bailey, 1996; Régnier et al. 2017). This is further complicated by the effect of climate change on local environmental conditions such as changing ocean currents and a possible shift in composition of copepod species.

Summary

- Kittiwake are surface feeders, feeding primarily on fish in open water, but they have a variable diet over their geographic range.
- At FFC SPA, sandeel is the principal prey species for kittiwake, particularly during the breeding season.
- Breeding adult kittiwake eat 1+ group sandeel in April/May and shift to smaller 0 group sandeels (fish hatched in the current year) for themselves and their young in June/July. As such, multiple healthy year classes of sandeel are important for kittiwake.
- Kittiwake are only able to feed on sandeel when they emerge from the sediment between April to November, with a peak in dietary composition in June/July corresponding to the appearance of shoals of 0 group sandeels near the surface.
- Kittiwake cannot utilise sandeel fully if there is a disparity in the timing of sandeel availability and when breeding kittiwakes require peak energy. Climate change has increased the likelihood of a misalignment due to a change in the time of the spring plankton bloom and hence sandeel emergence.

1.4 Guillemot and razorbill feeding strategy

1.4.1.1 Common guillemot (*Uria aalge*) (hereafter guillemot) is a large auk and one of the most numerous seabirds in the temperate and cooler seas of the northern hemisphere. It is also currently the most abundant seabird species in the North Sea (Mitchell et al. 2004).

1.4.1.2 Guillemots dive from the sea surface, using their wings to propel themselves underwater in pursuit of small fish, and can dive to at least 100 m. In the North Sea, guillemot feed predominately on sandeel in summer, with sprats being the main alternative prey source (e.g. Anderson et al. 2013). Guillemots in general may be more able to switch from a diet of sandeels to a diet of sprats than other seabird species (Wanless et al. 2018).

1.4.1.3 In winter, they take a more varied but mostly fish diet and unlike other seabirds can take sandeel when they are buried in the seabed by digging or scaring them out of the sediment. The foraging range of breeding guillemot is 33.1 km (mean), 73.2 km (mean maximum), and up to a maximum of 338 km (Woodward et al. 2019).

1.4.1.4 Razorbill (*Alca torda*) is another auk that uses its wings to propel itself underwater in pursuit of small fish prey. Where razorbill are different from common guillemot is that they tend to make shallower dives, feed more on sandeel and less on sprat, feed on smaller fish than common guillemots, and carry multiple fish down the bill rather than a single fish inside the bill. Moreover, razorbills make only pelagic dives whereas common guillemots make both benthic and pelagic dives (Chimienti et al. 2017). The foraging range of breeding razorbill is 61.3 km (mean), 88.7 km (mean maximum), and up to a maximum of 313 km (Woodward et al. 2019).

1.4.1.5 For both guillemot and razorbill in the North Sea, forage fish comprise a large component of their diet (around 70% for both species) (Engelhard et al. 2014). Of the forage fish, sandeel represents the highest proportion by mass followed by sprat and herring (ICES 2011). In particular, sprat is a significant component in the diet of razorbill and herring in the diet of herring compared to the other species.

1.4.1.6 Food shortage is an evident cause of reduced productivity for both guillemot and razorbill at some colonies in some years (Furness et al. 2013). The reproductive output of razorbill was probably limited by the availability of local sandeel at the Isle of May (Mitchell et al. 2004) and the provisioning of guillemot chicks was influenced by local abundance and quality of sandeel and sprat (Wanless et al. 2005).

1.4.1.7 However, following the closure of a large area off the east coast of Scotland to sandeel fishing in 2000 due to very low kittiwake breeding success, there was no observed effect on productivity of common guillemot or razorbill (Frederiksen and Wanless 2006) (see 1.6.17 for further discussion in relation to kittiwake). Furness and Tasker (2000) have suggested that food fish abundance might need to fall to lower levels to affect common guillemot or razorbill compared to kittiwake.

1.4.1.8 Furness et al. (2013) have suggested closing all sandeel and sprat fisheries in UK waters as a conservation measure most likely to benefit kittiwake and based on consideration of seabird foraging ranges. However, they acknowledge that the evidence this would affect either common guillemot or razorbill productivity is much less strong (and largely based on evidence from Scottish colonies).

1.4.1.9 Though both auk species can undoubtedly be impacted by food shortages they are likely much more resilient than kittiwake (Furness and Tasker 2000). In general, guillemot is considered to be better buffered against food shortage as kittiwake can only catch sandeel at the sea surface and at specific times of year (Wanless et al. 2005; Monaghan et al. 1994). Razorbill may also be able to switch to alternative food sources such as zooplankton if forage fish are scarce.

1.4.1.10 Despite foraging on the same prey, of the two auks, razorbills can breed more successfully at lower prey densities but need higher densities for self-maintenance, emphasizing the importance of considering species-specific traits when determining sustainable forage fish densities for top predators (Hentati-Sundberg et al. 2020).

1.4.1.11 Hentati-Sundberg et al. (2020) concluded that in their Baltic study case, densities of forage fish corresponding to the current fisheries management target B_{MSY} were sufficient for successful breeding of guillemot and razorbill (at current colony sizes), and that the fisheries management target for conserving seabirds proposed by Cury et al. (2011), 1/3 of historical maximum prey biomass ($B_{1/3}$), was also sufficient.

1.4.1.12 At Flamborough and Filey Coast SPA, common guillemot has increased from 62,100 at designation to 84,647 birds (in 2017) and razorbill from 15,776 at designation to 30,228 birds (in 2017). Compared to the rest of the UK, common guillemot and razorbill colonies on the North Sea coast, and particularly east England, have all increased. This may suggest that food shortages are more of a problem for more northerly colonies, particularly larger north Scotland colonies.

Summary

- Productivity of common guillemot and razorbill colonies can be severely reduced by food shortages.
- Both auk species are more resilient to changes in prey species compared to kittiwake due to their diving behaviour and the fact they utilise a wider variety of prey.
- There is little evidence that fisheries management results in an increase in productivity of either common guillemot or razorbill.
- Much less is known about foraging behaviour of common guillemot and razorbill from FFC SPA compared to kittiwake due to the difficulty in tracking with GPS at this site.
- UK SPA monitoring indicates that North Sea (and east England) colonies for both common guillemot and razorbill are increasing in bird numbers which may show there isn't a sufficient prey shortage to impact seabirds more resilient than kittiwake.

1.5 Sandeel fishery

1.5.1.1 Sandeels are the target of what has been the largest single-species fishery in the North Sea over recent decades. There is evidence that the sandeel fishery has contributed to depletion of sandeel biomass in the North Sea (Lindegren et al. 2018). Breeding, breeding success and survival rate of kittiwake are considered to be strongly influenced by sandeel stock size and thus by commercial fisheries on sandeels (Furness and Tasker 2000, Lewis et al. 2001, Oro and Furness 2002, Mitchell et al. 2004, Frederiksen et al. 2004).

1.5.1.2 Aebischer and Coulson (1990) reported at North Shields, United Kingdom, a mean kittiwake survival rate of 0.8 but with variation from 0.85 in 1954-1965 to only 0.65 in 1982-85. They suggested that the decrease in survival in the 1980s might most likely be due to changes in abundance of small pelagic fish including sandeel on which the kittiwakes depend. Oro and Furness (2002) showed that kittiwake breeding adult annual survival rates at a colony in Shetland varied between 0.98 and 0.53 (with a mean of 0.8), with a strong effect of sandeel abundance and a weak influence of great skua breeding success. Frederiksen et al. (2004) analysed environmental factors affecting survival rates of breeding adult kittiwakes at the Isle of May colony. They found that survival rate varied between 0.98 in 1986-87 and 0.82 in 1998-99, with 35 to 52% of the annual variation in survival rate being explained by the presence or absence of a commercial fishery for sandeels in the area and sea surface temperature (SST). Kittiwake survival was lower when there was a sandeel fishery and when SST was higher. This is consistent with the fishery depleting the North Sea sandeel stock, and with sandeel recruitment decreasing with higher SST (Arnott and Ruxton 2002). On average, kittiwake adult survival rate was reduced by about 0.05 during the period when a commercial fishery for sandeels was active in the area. The results presented by Frederiksen et al. (2004) are closely consistent with those of Oro and Furness (2002), but for kittiwake breeding in different regions, associated with different sandeel stocks, and with different commercial fisheries.

1.5.1.3 There is evidence that a reduction in the abundance of sandeels can cause a reduction in the breeding success and survival of kittiwakes, and that large reductions in sandeel abundance result in breeding failure of kittiwakes and population decline (Furness and Tasker 2000, Oro and Furness 2002, Frederiksen et al. 2004, Furness 2007, Carroll et al. 2017). Kittiwake breeding success, and breeding numbers, crashed in Shetland after the collapse of the Shetland sandeel stock (Furness and Tasker 2000). Kittiwake breeding success has also been affected at the Isle of May, off east Scotland, when the sandeel stock in that area (which is distinct from the sandeel stocks at Shetland or in the southern North Sea; Frederiksen et al. 2005; ICES 2019) was heavily fished (Frederiksen et al. 2004).

1.5.1.4 Frederiksen et al. (2004) also showed that breeding success of kittiwakes at the Isle of May (part of Forth Islands SPA) was on average 0.5 chicks per pair lower during years when sandeel fishing occurred in the area than it was in years with no sandeel fishing. Furthermore, on the Isle of May and across the Shetland isles, kittiwake breeding success was found to be related to abundance and availability of both juvenile and sandeels aged one and older (e.g. Daunt et al. 2008; Poloczanska et al. 2004; Rindorf et al. 2000). As a result of the persistent low breeding success of kittiwakes a decision was taken to close an area to sandeel fishery (the NW North Sea sandeel box off the east coast of Scotland) (see 1.6.1.7).

1.5.1.5 Kittiwake lay one to three eggs with a mean clutch size[3] of 2.01 in the British Isles (Cramp and Simmons, 1977-1994, del Hoyo et al., 1992-2006). Productivity, the number of chicks produced pre nest, at the Flamborough & Filey Coast SPA has declined since the 1980s (JNCC, 2015). Breeding success of the Flamborough & Filey Coast kittiwake population was 1.2 chicks/pair in 1986-1990, but fell to 0.8 chicks/pair in 2010-2014, with that reduction largely being attributable to high fishing mortality of sandeels resulting in a reduction in sandeel abundance (Carroll et al., 2017). The relationship found by Carroll et al. (2017) for kittiwakes at Flamborough & Filey Coast SPA in relation to sandeel stock in ICES North Sea SA1 (Dogger Bank and neighbouring areas) is similar to that previously identified at Shetland (Furness and Tasker, 2000, Oro and Furness, 2002, Furness, 2007), and at the Isle of May (Frederiksen et al., 2004).

<u>Summary</u>

- Sandeels are the target of what has been the largest single-species fishery in the North Sea over recent decades and there is evidence that this has contributed to a decrease in sandeel biomass in the North Sea.
- Breeding, breeding success and survival rate of kittiwake can be strongly influenced by sandeel stock size and thus by commercial fisheries on sandeels.
- There is evidence of a negative relationship between kittiwake productivity and sandeel fishing mortality at Flamborough & Filey Coast SPA, Shetland, and the Isle of May.

[3] Clutch size refers to the number of eggs laid in a single brood by a nesting pair of birds

1.6 Commercial fisheries interactions

1.6.1.1 The sandeel fishery is the largest single-species fishery (by weight) in the North Sea with historic landings of around a million tonnes per annum. The fishery started in the 1950s, reaching peak landings of around 1 million tonnes in the late 1990s, before declining to 100,000 to 400,000 tonnes per year since 2003 (Furness, 2002, ICES, 2015a). Landings have decreased primarily due to a reduction in the productivity of sandeel in the northern North Sea where recruitment has decreased to less than half the average of earlier years. Since the early 2000s the fishing fleet has declined in size, but in spite of this, sandeel stock biomass has declined and is often below stock reference points (ICES, 2015a). Despite the reduction in the fishery, landings of sandeel in 2009 were still higher than those for all demersal fish species combined (Engelhard et al. 2014).

1.6.1.2 Forage fish are mainly targeted through midwater pelagic trawls. Pelagic trawl and seine fisheries operate throughout most parts of the North Sea, except in the eastern portion of the central North Sea. The small-meshed (< 32 mm codend) pelagic trawl fishery is dominated by vessels >40 m who target sandeel, Norway pout, sprat, and blue whiting for reduction purposes. The pelagic trawl fishery for human consumption is operated by refrigerated seawater trawlers (>40 m) and freezer trawlers (>60 m) and targets herring, mackerel, and horse mackerel. Some blue whiting is taken by these vessels in the northern North Sea (ICES, 2020). Since 2003, the pelagic fisheries using pelagic trawl and purse seines have accounted for the largest proportion of the total landings from the Greater North Sea, followed by the demersal and benthic fisheries.

1.6.1.3 ICES who advise the European Commission on the Total Allowable Catch (TAC) of sandeel, define the fishery as follows:

> *Sandeels are taken by trawlers using small mesh gear. The fishery is seasonal, taking place mostly in the spring and summer. Most of the catch consists of Ammodytes marinus and there is little by-catch of protected species. The I-group constitutes the major part of the catches. The Dogger and Fisher Bank fisheries are the most important fishing grounds. The North Sea sandeel catches are taken almost exclusively by Denmark and Norway.*

1.6.1.4 A spatial and temporal overlap exists between sandeel fisheries and kittiwake feeding grounds. The major sandeel fishing grounds are located approximately 100 km from the UK coast with some smaller grounds closer to the coast but still offshore (>12 nmi) (see Error! Reference source not found.) (ICES 2007; Jensen et al. 2011; South et al. 2009) and so o verlap with seabird foraging areas. The mean maximum foraging range for kittiwake is considered to be approximately 156 km, however GPS tracking studies have shown that kittiwakes from Flamborough and Filey Coast SPA also forage within the Dogger Bank area of the southern North Sea.

1.6.1.5 Sandeel fishing occurs in April to June and the fleet mainly target year one or older sandeels through use of a specific mesh size. Depending on the timing of the fishery relative to the timing of the switch in diet from year one or older sandeels to juvenile sandeels, fisheries may directly compete with breeding kittiwakes when energetic demands are high. As such, it is especially important to consider the sensitivity of the seabirds during the breeding season when considering potential impacts of the fishery. Furthermore, effects in subsequent years are also likely to accrue through the overall reduction in the abundance of older sandeels (Carrol et al. 2017), particularly where fishing reduces the spawning stock to the point where egg production limits the numbers of juvenile fish (Daunt et al. 2008).

1.6.1.6 In Shetland, sandeel stock biomass fell rapidly in the late 1980s during the period of a local industrial fishery for sandeels, and that fishery was closed in 1990. Breeding success of kittiwakes in Shetland in 1990 was 0.12 chicks per pair. In 1991, the first year of the sandeel fishery closure, sandeel recruitment was higher than it had been in any of the previous seven years during heavy fishing. Kittiwake productivity in 1991 was 0.57 chicks per pair, the highest at monitored Shetland colonies since 1986 (JNCC data and ICES sandeel stock data).

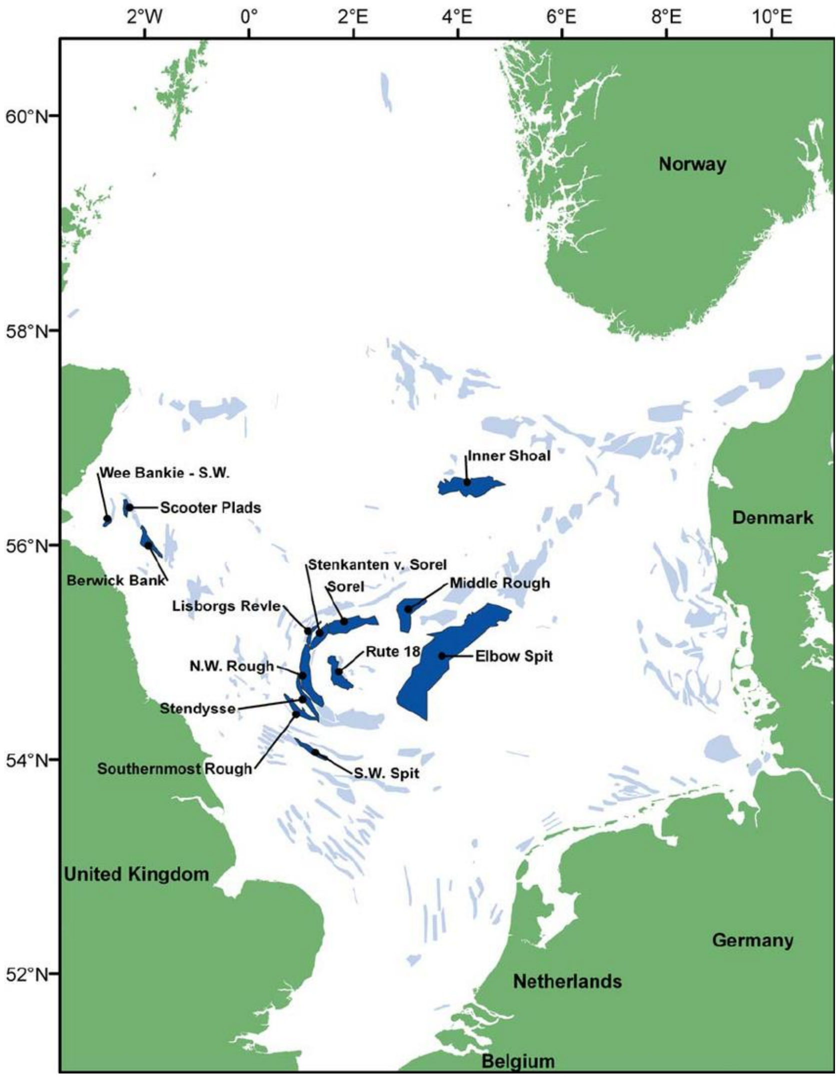

Figure 1.1 Location of sandeel habitat areas (areas with potentially high density of non-buried sandeel)

1.6.1.7 An area off the east coast of Scotland was closed to sandeel fishing from 2000 because kittiwake breeding success in the area had fallen to very low levels (EC, 2000, Wright et al.

2002). Intensive fishing for sandeels for several years by the Danish industrial fleet[4] on the sand banks close to the east coast of Scotland was considered to be the main cause (Wright et al. 2002). The aim of this fishery closure was to allow sandeel stocks in the area to recover. The abundance of 0 and 1+ sandeel age classes increased markedly in 2000, the first year of fishery closure (Greenstreet et al. 2006). The large increase in 1+ group sandeel abundance in 2000 was likely to be the combined effects of a substantial decline in fishery removals of sandeels of this age group in 1999 and coincidental recruitment of a stronger 0 group cohort in 1999 compared with that in 1998 (Greenstreet et al. 2006, Daunt et al. 2008).

1.6.1.8 Frederiksen and Wanless (2006) reviewed the evidence that the sandeel closure increased productivity of kittiwakes and other seabirds. They found that the closure appeared to result in increased productivity of kittiwake within the study area compared with a control area outside the closure. Productivity of kittiwakes did not differ between fishery and non-fishery years outside the closure zone, but inside the zone breeding productivity was considerably lower during fishery years (the difference was 0.28 chicks per nest and statistically highly significant ($p<0.0001$). Daunt et al. (2008) and Frederiksen et al. (2008) also found an initial increase in kittiwake breeding success at colonies within the closed area compared to those outside, providing evidence for the mitigation of fishery impact by closing the fishery.

1.6.1.9 However, monitoring of seabird breeding performance in the area continued in 2004-5 and success was poor across all species in 2004 and all except kittiwakes in 2005 despite the continued closure of the fishery (Mavor et al. 2005, Parsons, 2005). It is now thought that closing the area to fishing has been insufficient to maintain high sandeel biomass in the area (Greenstreet et al. 2010). Recruitment of young sandeels at levels at least comparable to the long-term average is also critical and this is governed by natural processes. In the absence of continued high recruitment, natural sandeel mortality exceeds growth production and population biomass has declines. Greenstreet et al. (2010) concluded that:

> *"Closing industrial fisheries for short-lived, highly-productive species such as sandeels appears to provide no guarantee of ensuring high abundance of these species in the managed area. Thus, closed area management does not ensure that prey supplies to marine top predators remain at levels sufficient to support continuous strong reproductive performance. At best it ensures that anthropogenic activities, such as industrial fishing, are not directly responsible for predator population collapses."*

1.6.1.10 As aforementioned, breeding success and productivity of kittiwake at the Flamborough and Filey Coast SPA has been found to correlate with sandeel abundance (Carroll et al. 2017). Lindegren et al. (2018) carried out a hindcast analysis of the Dogger Bank sandeel stock to assess the consequence of high fishing mortality. They estimated that sandeel spawning stock biomass would have been about double what it is now, if the fishery had maintained fishing mortality (F) at F=0.4 rather than at the levels of 0.8 to 1.2 as seen

[4] Off Scotland, small sandeel fisheries operate at Shetland and off the west coast. These fisheries are rather different in character to the large North Sea sandeel fishery. They are smaller in scale and restricted to small inshore grounds and managed nationally. The Shetland fishery was not thought to have had a significant effect on the availability of sandeels to seabirds. However, subsequent management of the fishery has explicitly recognised the importance of the Shetland sandeel population to seabirds.

during 1999-2009. Their results suggest that in some years high fishing mortality of the sandeel stock has had an influence on the abundance of the sandeel.

1.6.1.11 At present, sandeel stock remains considerably below its long-term average and subject to a fishing mortality around F=0.6[5] (ICES, 2018). The spawning stock biomass in SA1 was also at a dangerously low level of 67,711 tonnes in 2019, which is less than 10% of its highest historical level and is slightly below the limiting spawning stock biomass at which ICES should recommend closure of the fishery (B_{lim} of 110,000 tonnes SSB) because there is a serious risk of recruitment failure in this stock (ICES, 2019). Despite this the quota set for the Danish sandeel fishery, which is by far the main EU fishing nation for sandeel, has been set at 215,863 metric tons, double the quota in 2019 which was 106,387 metric tons. Furthermore, the stock assessment model used by ICES does not take full account of real-word variability and variance is therefore underestimated by the model. The result is that a Total Allowable Catch (TAC) may be set at a higher level than required to meet management objectives[6].

1.6.1.12 High fishing mortality has been found to be associated with reduced spawning stock biomass in each of the next two years, and lower kittiwake breeding success two years later (Carrol et al. 2017). It is possible that the lag may be due to the fishery focussing on year one and two sandeels and the ability of kittiwake to switch to juvenile sandeel, thus providing an initial buffer on impacts (Carrol et al. 2017). Further, as populations decline, sandeel distributions contract into core habitats (Wright et al. 2000). It is therefore possible that smaller sandeel aggregations closer to the coast could become depleted over time with this reduction in food availability leading to a lagged response on kittiwake populations. However, available data are currently insufficient to be able to determine possible mechanisms for the lagged response.

1.6.1.13 Closed areas are a management option for sedentary, short-lived species subject to a directed fishery (i.e. sandeel), because protected habitats support all age classes, and rapid recovery in species abundance is more likely (Gell and Roberts, 2003, Sale et al. 2005). Following closure of a sandeel fishery along the east coast of Scotland, there was an immediate increase in sandeel abundance (Greenstreet et al. 2006). This increase was most likely the result of improved survival of sandeels year one or older, previously the target of the fishery, combined with coincidental high levels of recruitment (Greenstreet et al. 2006).

1.6.1.14 Hentati-Sundberg et al. (2021) highlight that of the 14 sprat and herring stocks currently managed with advice from ICES (www.ices.dk/advice), the mean size of the management area is 720,000 km^2, suggesting that this type of spatial mismatch is a general pattern. This indicates a need for protection of important foraging areas of seabirds at appropriate spatial scales in addition to general fisheries management practices.

1.6.1.15 Cury et al. (2011) suggested that fisheries management should aim to keep food fish stocks such as sandeels above a threshold of one-third of their historical maximum biomass in order to achieve good productivity among dependent seabird populations. The southern

[5] A figure above the level tested in the scenario of Lindegren *et al.* (2018), and which their scenario modelling clearly demonstrates has a negative impact on sandeel abundance.
[6] Management metric equals <0.05 risk of spawning stock biomass being depleted below the reference point threshold at which fishing should be closed to save the stock from commercial extinction (ICES, 2017)

North Sea sandeel stock has fallen far below that rule of thumb management objective. Daunt et al. (2008) suggest that fishery closures could have a beneficial impact on top predators sensitive to variation in abundance of target species, although environmental conditions before and after closure are likely to be highly important.

Summary

- The sandeel fishery has been the largest single-species fishery (by weight) in the North Sea with historic landings of around a million tonnes per annum.
- The sandeel fishery is offshore (>12 nmi), seasonal, taking place mostly in the spring and summer, and may directly compete with breeding kittiwakes when energetic demands are high.
- The SA1 sandeel population remains below precautionary limits to ensure future recruitment and is regularly fished beyond the 'one third [of unfished biomass] for the birds' rule (Cury *et al.*, 2011) and with age-1 fishing mortality (F) >0.5 (Carroll *et al.*, 2017)
- An area off the east coast of Scotland was closed to sandeel fishing from 2000 because kittiwake breeding success in the area had fallen to very low levels.
- The success of the closure is difficult to evaluate as an initial increase in kittiwake breeding success can be partly attributed to coincidental high recruitment of sandeel as well as a decline in fishery removals. Subsequent monitoring has shown that a continued ban on sandeel fishing in the area has failed to maintain sandeel biomass at initial high levels.
- Reducing fishing mortality in SA1 is unlikely to reverse widespread kittiwake declines due to sandeel recruitment variability, but some colonies in eastern England may benefit.

1.7 Sandeel fishery management

1.7.1.1 ICES is the sole scientific advisor for North Sea shared and/or international stocks that come under the Common Fisheries Policy (CFP), and CFP/Norwegian responsibilities. The legitimacy of this role is provided through a grant agreement with the EU and with Norway.

1.7.1.2 ICES has signed a Memorandum of Understanding[7] (MoU) with the government of the United Kingdom (UK). With this, ICES will provide the UK with scientific information and advice relating to the North Atlantic and its adjacent seas. The agreement includes annual advice on fishing opportunities, as well as information on the state of marine ecosystems and the impacts of human activities. The UK may also request ICES advice on an ad hoc basis. The MoU took effect as of 1 January 2021 and will be reviewed and possibly revised every third year.

1.7.1.3 ICES does not play a role in the enforcement, monitoring of fisheries or the management. ICES is also a science advisor to the EU Directorate-General for Environment (DGENV) on

[7] UK_MOU.pdf (ices.dk)

the Marine Strategy Framework Directive (MSFD). All ICES advice is aimed at providing advice under the ecosystem approach and the precautionary approach. ICES Maximum Sustainable Yield (MSY[8]) advice rule:

> *The production in a fish stock can be highly variable. It is related to stock size (often expressed as spawning–stock biomass, SSB) and the size structure in the stock, which in turn depend also on the fishing mortality and fishing pattern.*
>
> *Surplus production of a stock is the catch that can be harvested without changing the average production in the long term. For a given fishing pattern there is a level of fishing mortality that in the long term will generate the highest surplus production. This peak of the surplus production is the MSY, and the fishing mortality generating this peak is FMSY.*
>
> *Fishing mortality is the only variable that can be directly controlled by fisheries management. Fisheries management cannot directly control the stock size, it can only influence it through the fishing mortality. Stock size is also subject to natural variability that on a year-to-year basis can overwhelm the influence of fishing. MSY is a long-term average. A management strategy that harvests variable yields in response to the natural variability in stock size will on average give yields closer to the long-term MSY than a strategy operating with the maximum constant yield that could be taken sustainably.*
>
> *Due to the natural variability in stock size there may be situations where the spawning stock is so low that reproduction is at significant risk of being impaired. A precautionary approach implies that fisheries management in such situations should be more cautious. For stocks where quantitative information is available, a reference point B_{lim} may be identified as the stock size below which there may be reduced recruitment. A precautionary safety margin incorporating the uncertainty in ICES stock estimates leads to a precautionary reference point B_{pa}, which is a biomass reference point designed have a low probability of being below B_{lim}. In most cases the safety margin is taken as a standard value, such that in most cases $B_{pa} = B_{lim} \times 1.4$. When the spawning stock size is estimated to be above B_{pa}, the probability of impaired recruitment is expected to be low.*
>
> *For short-lived species, the biomass can fluctuate wildly between years. A precautionary approach in this situation implies that a minimum stock size, $B_{escapement}$, should remain in the sea every year after fishing.*

1.7.1.4 Sandeel catches in EU waters are managed through seven area TACs which are set at the beginning of every year according to an escapement strategy (**Figure 1.2**).

1.7.1.5 For short-lived stocks, such as sandeel, ICES consider their MSY approach to be "escapement fishing" where the fishery each year aims to reduce the stock size to a biomass consistent with having a specific, low probability of impairing recruitment and that is a sufficient resource for predators (Dickey-Collas et al. 2014; ICES 2015b). However, some fisheries scientists have disputed that management of this fishery contains any predator-focused reference point in the management process (Hill et al. 2020).

[8] In fisheries, MSY is defined as the maximum catch (in numbers or mass) that can be removed from a population over an indefinite period.

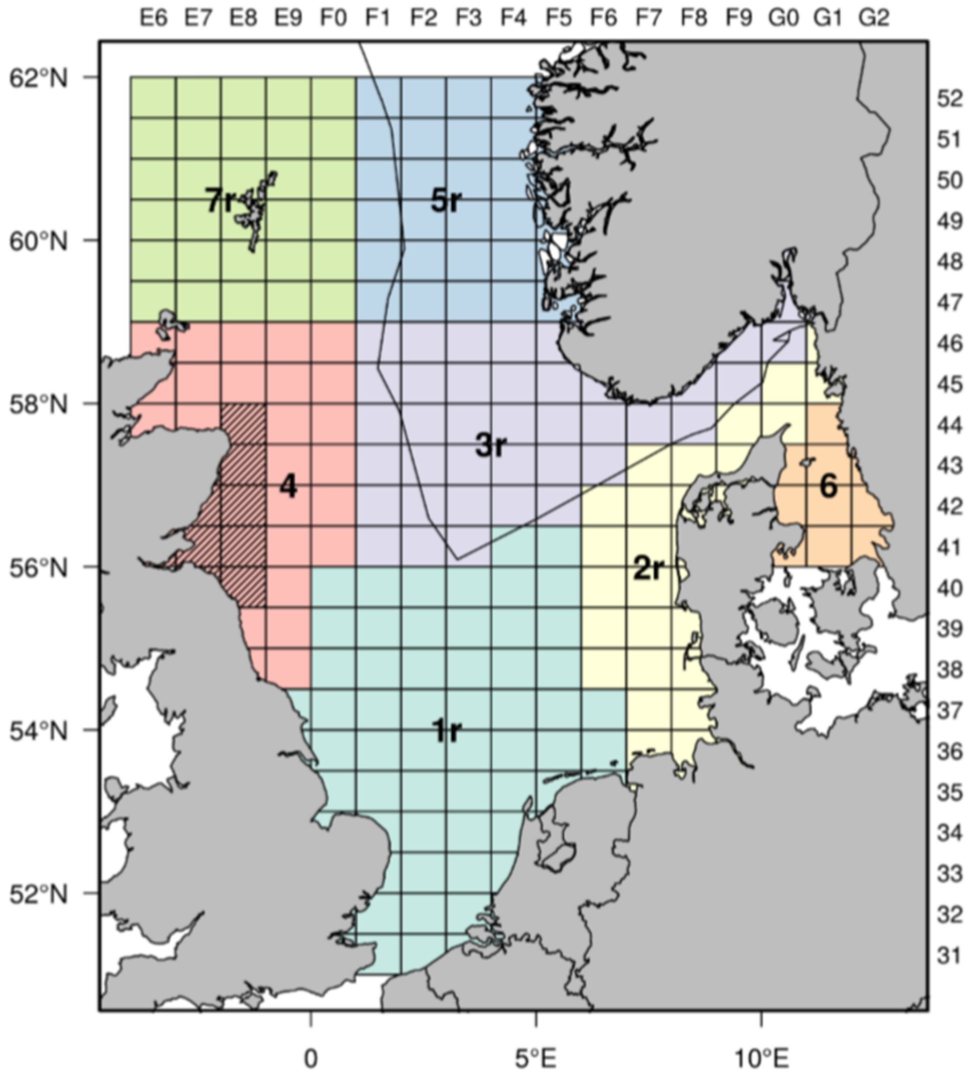

Figure 1.2 Sandeel in divisions 4.b–c, Sandeel Area 1r. Stock areas for the seven sandeel stocks. The border of the Norwegian Exclusive Economic Zone (EEZ) is also shown. The closed part of Sandeel Area 4 is shown with hatched markings.

1.7.1.6 For sandeel in SA1r corresponding to the southern North Sea, the spawning-stock biomass (SSB) was below B_{lim} and B_{pa} = MSY $B_{escapement}$ in 2019 and at the beginning of 2020 (**Figure 1.3**), indicating potentially impaired recruitment (**Table 1.1**). ICES assesses that the spawning-stock size is currently below MSY $B_{escapement}$ and B_{pa} but above B_{lim}.

1.7.1.7 The catch advice for 2021 has decreased compared to 2020 because the 2020-year class is below average and a large reduction in fishing mortality is required to bring the SSB above MSY $B_{escapement}$ at the start of 2022. ICES is not aware of any agreed precautionary management plan for sandeel in this area.

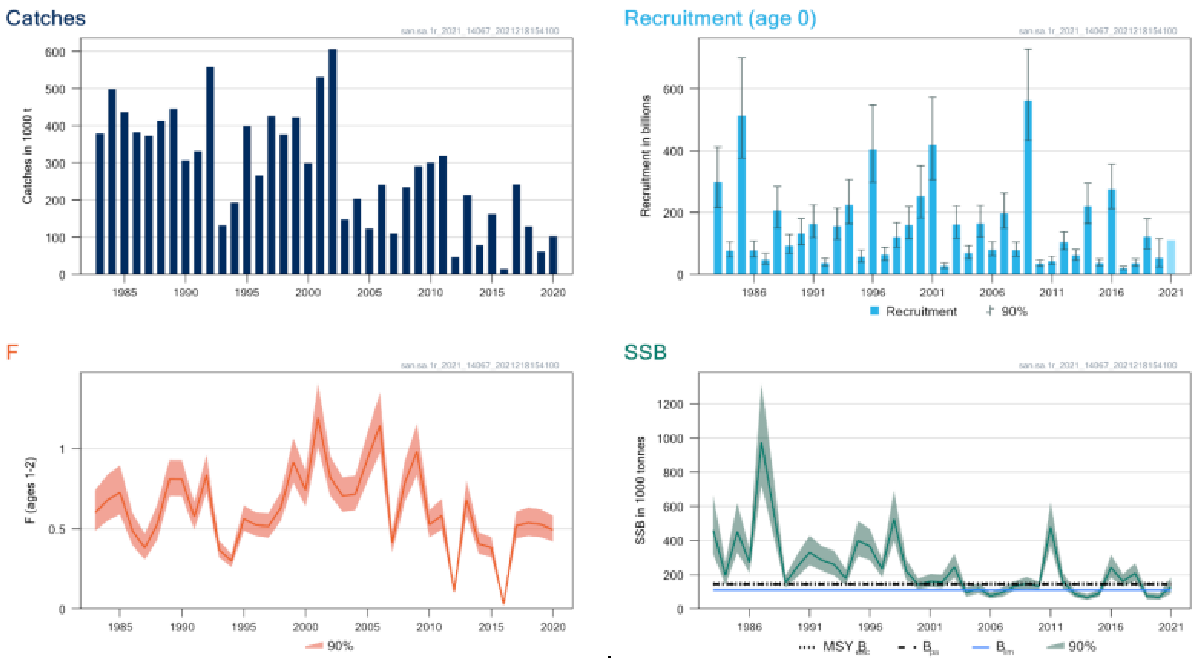

Figure 1.3 ICES Advice 2021 Sandeel in divisions 4.b-c, Sandeel Area 1r. Summary of the stock assessment. The assumed recruitment value for 2021 is shaded in a lighter colour.[9]

Table 1.1: ICES Advice 2020 Sandeel in divisions 4.b–c, Sandeel Area 1r. State of the stock and fishery relative to reference points

		Fishing pressure					Stock size			
		2017	2018	2019			2018	2019	2020	
Maximum sustainable yield	F_{MSY}	?	?	?	Undefined	MSY $B_{escapement}$	✓	✗	✗	Below escapement
Precautionary approach	F_{pa},F_{lim}	?	?	?	Undefined	B_{pa},B_{lim}	✓	✗	✗	Reduced reproductive capacity
Management plan	F_{MGT}	–	–	–	Not applicable	B_{MGT}	–	–	–	Not applicable

1.7.1.8 In England, Natural England and JNCC are inshore and offshore statutory nature conservation bodies respectively and who advise authorities when fisheries may be having an impact on the feature of a marine protected area (MPA).

[9] san.sa.1r (ices.dk)

Summary

- ICES is the sole scientific advisor for North Sea shared and/or international stocks that come under the CFP, and CFP/Norwegian responsibilities
- For sandeel, the biomass can fluctuate wildly between years due to variable recruitment and a very short lifecycle. The ICES precautionary approach implies that a minimum stock size, $B_{escapement}$, should remain in the sea every year after fishing.
- Sandeel catches in EU waters are managed through seven area TACs which are set at the beginning of every year according to an escapement strategy. For Area 1r, corresponding to the southern North Sea, SSB was below B_{lim} and B_{pa} = MSY $B_{escapement}$ in 2019 and 2020, indicating potentially impaired recruitment.

1.8 Relationships between sandeel biomass and kittiwake at FFC SPA

1.8.1.1 The Applicant carried out statistical modelling to look at relationships between changes in sandeel spawning stock biomass (SSB) in the stock management area SA1 and the kittiwake population at FFC SPA (DMP Stats, 2020; Annex A). Based upon advice from Natural England following the workshop on 11 August these followed the approach of Carroll et al. (2017). These results should be interpreted with caution as there are a number of major necessary assumptions and approximations underpinning these results (see Annex A).

1.8.1.2 Rudimentary calculations were conducted based on Carroll et al. (2017) and the most recent SA1 stock assessments, providing estimates of the increases in chick numbers from increases in productivity (via probability of fledging). This productivity increase is expressed as a function of increased sandeel SSB and an implied decrease in fishing mortality (*F*).

1.8.1.3 Naïve calculations were conducted with approximated parameter uncertainty based on Carroll et al. (2017), providing estimated changes in chick numbers. These estimated approximately 175 to 237 additional chicks for an increase of 2% in SA1 sandeel SSB, equivalent to a 0.5% increase in kittiwake productivity or decrease of 4% in fishing mortality in the preceding year.

1.8.1.4 A series of Population Viability Analysis (PVA) style simulations were further run to estimate the effects of SSB changes on the population structure of the FFC SPA kittiwakes, in particular adult numbers, assuming a range of reduced mean fishing mortalities.

1.8.1.5 The smallest reduction in fishing mortality (<4% of 2018 levels) considered within these PVAs resulted in a median of 190 additional adults after five years, with 147 additional adults projected at the 2.5th percentile of simulations i.e. a nominal 95% lower confidence bound.

1.8.1.6 Sandeel SSB is hugely variable, driven by large variability in recruitment year-to-year, which in turn can be influenced by several environmental factors including SST and changes in local hydrodynamics. This source of natural variability far exceeds other sources of variance in the explorations here (see Figure 1.3), rendering many of the speculative changes to fishing mortality relatively insignificant, and very unreliable, in terms of increasing adult numbers.

1.8.1.7 The outputs suggest that, because of the large inter-annual variability in sandeel recruitment combined with short lifecycle, management of the fishery is not scalable to the compensation levels required for the Applicant (a minimum of 73 kittiwake). Even at a larger scale, it is far from certain that any fisheries management would have a sustainable benefit to sandeel stocks as seen in the north-western North Sea sandeel closure. Were it deemed necessary from a wider nature conservation perspective, then a government-led ecosystem-based approach could be employed to consider impacts, and hence potential benefits through management, to multiple protected predators of sandeel.

Summary

- Models based on Carroll *et al*. (2017) and the most recent SA1 stock assessments show that a 4% reduction in 2018 fishing mortality resulted in a median of 190 additional adults after five years, with 147 additional adults projected at a nominal 95% lower confidence bound.
- These results should be interpreted with caution as there are a number of major necessary assumptions and approximations underpinning these results
- Sandeel SSB is hugely variable, driven by large variability in recruitment year-to-year and a short lifecycle. This source of natural variability far exceeds other sources of variance in the explorations here, rendering many of the speculative changes to fishing mortality relatively insignificant, and very unreliable, in terms of increasing adult numbers.
- Management of the sandeel fishery to increase sandeel SSB is not scalable to the compensation levels required for the Applicant (a minimum of 73 kittiwake). Even at a larger scale, it is uncertain that any fisheries management would have a lasting benefit to sandeel stocks and hence increase availability to kittiwake.

1.9 Sprat and herring fisheries management

1.9.1.1 Like sandeel, North Sea sprat and herring are short-lived species that experience high levels of natural mortality. The ICES MSY approach for these stocks is aimed at achieving a high probability of having a minimum biomass left to spawn the following year so that the stock is capable of producing MSY. For catch advice, ICES uses a different approach than for longer-lived species and defines a biomass reference point, MSY $B_{escapement}$, which is the biomass that should remain after the fishery has taken place. For some short-lived stocks, an F reference point, F_{cap}, is also used to limit exploitation when biomass is high as large biomasses are often estimated with greater uncertainty.

1.9.1.2 For the purposes of this review, the most relevant sprat (*Sprattus sprattus*) stocks are those from ICES Subarea 4: North Sea[10] as they relate to seabirds foraging from the Flamborugh and Filey Coast SPA.

1.9.1.3 For sprat in Division 3.a and Subarea 4 corresponding to the Skagerrak, Kattegat, and North Sea, the spawning stock biomass (SSB) was in excess of MSY $B_{escapement}$ from 2019-21 (**Figure 1.4**).

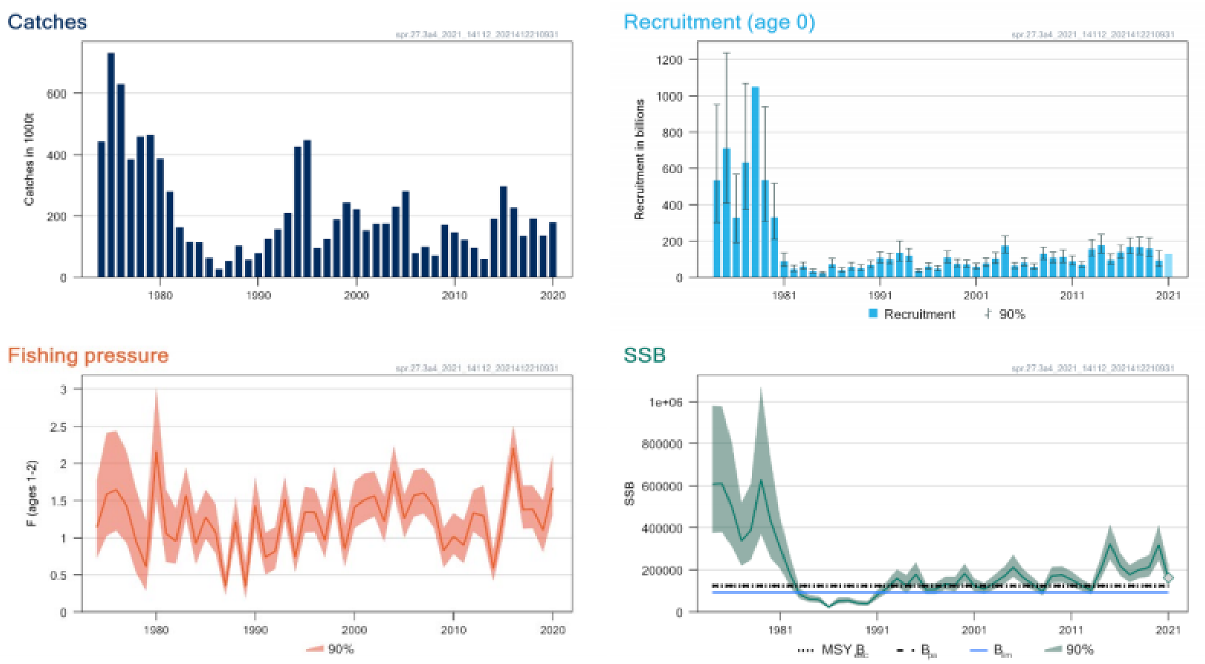

Figure 1.4 ICES Advice 2021 Sprat in Division 3.a and Subarea 4.. Summary of the stock assessment. Years refer to the modelled year July to June; recruitment and SSB as of July 1st. The paler shaded recruitment is assumed, and diamond SSB value is predicted.

Table 1.2: ICES Advice 2020 Sprat in Division 3.a and Subarea 4. State of the stock and fishery relative to reference points.

		Fishing pressure				Stock size			
		2017	2018	2019		2018	2019	2020	
Maximum sustainable yield	F_{MSY}	?	?	?	Undefined	MSY $B_{escapement}$	✔	✔	✔ Above escapement
Precautionary approach	F_{pa},F_{lim}	?	?	?	Undefined	B_{pa},B_{lim}	✔	✔	✔ Full reproductive capacity
Management plan	F_{MGT}	–	–	–	Not applicable	B_{MGT}	–	–	– Not applicable

1.9.1.4 ICES Advice (2020) states that for sprat their advice is based on the MSY escapement strategy (with an F_{cap}), which relies on a prediction of SSB after the fishery has taken place. A high proportion of the predicted SSB consists of recruits from the previous year for which

[10] Though following the most recent ICES benchmark workshop on sprat (WKSPRAT) this stock was merged with the Skagerrak-Kattegak (ICES 2018b).

the abundance and proportion of mature fish at spawning time is unknown. This contributes to the uncertainty in the forecast, which is accounted for by the F_{cap}.

1.9.1.5 Higher than average recruitment in recent years has contributed to an increase in SSB well above MSY $B_{escapement}$ in recent years (**Table 1.2**). The F_{cap} of 0.69 is used to ensure that after the fishery has been conducted, escapement biomass is preserved above B_{lim} with high probability. This is intended to ensure a median SSB above MSY $B_{escapement}$ in the long term (ICES, 2018b). However, the mean weight-at-age is decreasing over time, which is taken into account by using a recent average in the forecast.

1.9.1.6 For herring (*Clupea harengus*), the most relevant ICES Advice is for Subarea 4 and divisions 3.a and 7.d, autumn spawners (North Sea, Skagerrak and Kattegat, and eastern English Channel). SSB has fluctuated between 1.5 and 2.7 million tonnes between 1998 and 2018, and in all years was above MSY $B_{trigger}$ (**Figure 1.5**). Fishing mortality (F) has been below F_{MSY} since 1996. Recruitment has however been relatively low since 2002, with very low recruitment in 2015 and 2017. ICES assess that fishing pressure on the stock is below F_{MSY}, F_{PA}, and F_{lim}; and that the spawning stock size is above MSY B_{pa}, and B_{lim} but below MSY $B_{trigger}$ (**Table 1.3**).

1.9.1.7 The advice has increased by 38.4% because the updated assessment revised the estimates of stock size upwards. The fishing pressure on this stock is calculated over ages 2–6. In recent years, however, relative fishing pressure on older ages (7+) is higher and the proportion of older fish in the catches is increased; this is expected to result in higher catches in 2020.

1.9.1.8 Although the advice for 2020 was for an increase in catch, ICES expect a reduction in stock size in the coming years. This is because there is a lack of strong incoming year classes, as well as a reduction in the contribution of the strong 2013 year class to the stock. The SSB in 2020 is expected to be below MSY $B_{trigger}$, as a consequence of fishing at F_{MSY}.

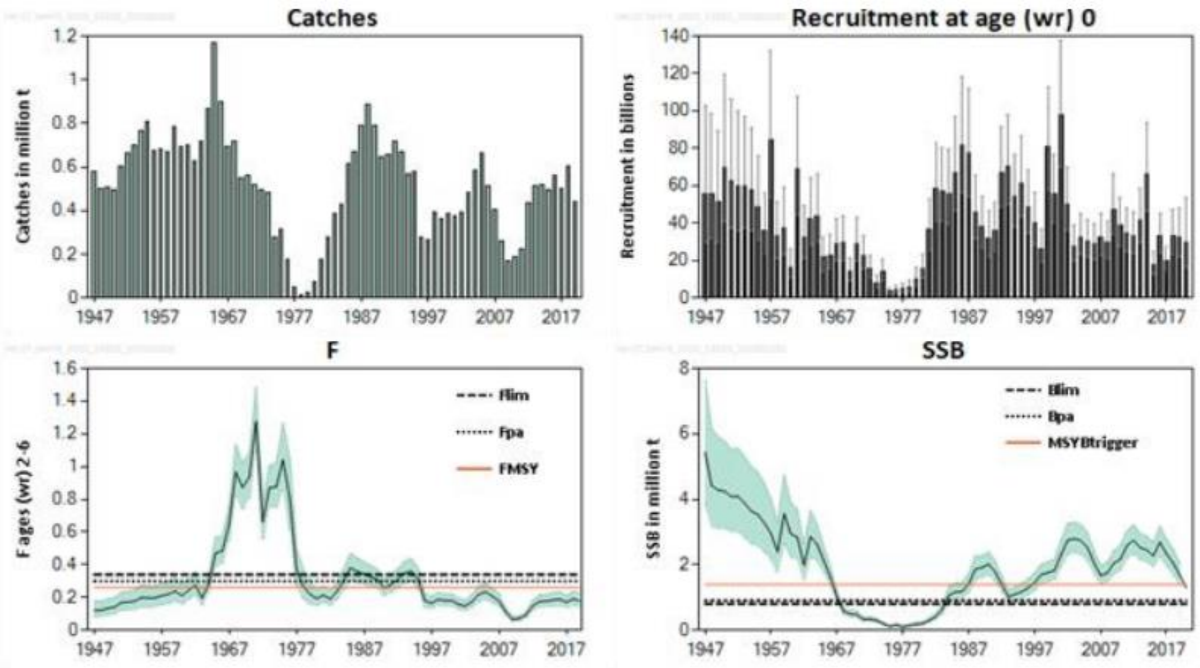

Figure 1.5 ICES Advice 2020 Herring in Subarea 4 and divisions 3.a and 7.d, autumn spawners. Summary of the stock assessment; 95% confidence intervals are shown for SSB, F, and recruitment.

Table 1.3: ICES Advice 2020 Herring in Subarea 4 and divisions 3.a and 7.d, autumn spawners. State of the stock and fishery relative to reference points.

	Fishing pressure					Stock size				
		2017	2018	2019			2018	2019	2020	
Maximum sustainable yield	F_{MSY}	✓	✓	✓	Below	MSY $B_{trigger}$	✓	✓	✗	Below trigger
Precautionary approach	F_{pa}, F_{lim}	✓	✓	✓	Harvested sustainably	B_{pa}, B_{lim}	✓	✓	✓	Full reproductive capacity
Management plan	F_{MGT}	–	–	–	Not applicable	B_{MGT}	–	–	–	Not applicable

1.9.1.9 Recent management strategy evaluations found that the ICES MSY advice rule with current F_{MSY} and MSY $B_{trigger}$ was not in fact precautionary (probability of SSB < B_{lim} higher than 5%) under the assumptions of those simulations (ICES, 2019c). This can be explained by technical differences in the evaluation approach use for the MSE compared to the standard approach to estimate MSY reference points. Further investigation is now required to establish if the current reference points need to be re-defined. In the interim ICES will continue to use the current reference points for advice.

1.10 Overview of evidence gaps

1.10.1.1 The aim of this section is to provide a summary evaluation of the available information supporting the compensation proposals to assist the interpretation of the evidence base.

Discussion with stakeholders around the importance and relevance of the identified limitations in the evidence base is ongoing.

1.10.1.2 Notwithstanding the reported correlations between fishing mortality and trends in sandeel biomass, the exact nature and strength of these correlations (and how they might relate to trends in predator populations) remain difficult to describe or predict. This is due to the complex inter-relationships among the fishery, sandeels and seabirds, a paucity of high-quality data on ecosystem function (including relationships among primary and secondary production, prey and predators) and the relevance of environmental conditions before and after a fishery closure, which are likely to be critically important (Daunt et al. 2007).

1.10.1.3 The significant relationship between sea surface temperature and sandeel spawning stock biomass (SSB), with higher SSB associated with lower temperatures (Carroll et al. 2017), for example, is likely to increasingly (as the climate changes) complicate understanding. This in terms of the implications for sandeel, their prey and fish, as the dominant source of predation mortality on sandeels (MacDonald, 2019).

1.10.1.4 Further, site-attached populations of sandeel vary markedly in density according to local productivity and mortality processes (Wright et al. 2019). Given this, and the need for monitoring and research across the trophic levels, the knowledge is not available to predict, quantify, separate or accurately match management actions to reported trends that may occur as a result of changes in climate as well as anthropogenic uses. Such are the complexities of marine ecosystems, it could be that no apparent variation in trends masks a significant positive effect on sandeel recruitment (MacDonald et al. 2019).

1.10.1.5 At the higher trophic levels, more knowledge is also needed to explain the precise mechanisms linking kittiwake breeding success to variations in sandeel abundance and fishing activity (Daunt et al. 2007), or where these mechanisms are limited for other predatory seabird species.

1.10.1.6 The methods applied to estimate trends in sandeel biomass (i.e. stock abundance assessments) have known limitations. Greenstreet *et al.* (2006) found that different survey methods (acoustic, demersal trawl, and nocturnal grab survey) which assess different components of the sandeel population provide inconsistent estimates, such that it was not possible to determine whether observed sandeel population biomass increases were related to the closure of a Scottish sandeel fishery. The International Council for the Exploration of the Sea (ICES) has referred to the difficulties evaluating changes in sandeel abundance due to the lack of a single reliable sampling method (ICES, 2016).

1.10.1.7 Although there is evidence that food shortages can reduce productivity at some common guillemot and razorbill colonies in some years, the evidence is much less clear than it is for kittiwake. Observations from the 2010 Scottish sandeel fishery closure were that there was no impact on either auk species. Although, this may have been because the food shortages impacted kittiwake first and were not severe enough to affect guillemot or razorbill.

1.10.1.8 For both common guillemot and razorbill, population sizes are increasing in colonies on the east coast of England which may indicate that food shortages are not a constraint for these species at Flamborough and Filey Coast SPA.

1.10.1.9 In addition to extrinsic factors, such as fisheries and climate change, kittiwake population size is influenced (as well as by other factors) by juvenile and immature survival rates, productivity and age at recruitment. The Offshore Wind Strategic Monitoring Research Forum (OWSMRF) hosted a workshop in February 2020 to identify research opportunities in relation to kittiwake population dynamics which had been identified by nature conservation stakeholders (JNCC, NE, SNH, MSS, RSPB) as a key uncertainty relating to UK windfarm consent (see **Appendix A**). JNCC organised a workshop that aimed to identify research opportunities to improve understanding of kittiwake population dynamics and drivers of population change, thereby improving our ability to predict population response to novel impacts. The need to improve understanding of the wider context to reduce uncertainties in population viability analyses modelling and clarify drivers of population change were cited by the JNCC as core objectives to address gaps in current understanding (Ruffino *et al.* 2020).

1.11 Summary of findings

1.11.1.1 The following key conclusions are drawn from the evidence review presented above:

- Sandeel are highly important prey species for kittiwake and can comprise up to 60% of the kittiwake diet on the east coast of England where FFC SPA is located;
- Sandeel are also an important prey species of common guillemot and razorbill, but these seabirds have a more varied diet than kittiwake and can access sandeel in locations and times of year where kittwake can not;
- The sandeel fishery has been in recent years, the largest single-species fishery in the North Sea and the sandeel stock biomass has declined often to a point that is below precautionary stock reference points;
- The biomass of European sprat and Atlantic herring stocks are currently above MSY $B_{escapement}$ and MSY $B_{trigger}$ though recruitment has been low for herring since 2002;
- There is a temporal and spatial overlap between breeding kittiwake and key sandeel fisheries which can exacerbate impacts of fishing during the sensitive breeding season;
- Accessibility of sandeel to kittiwake during the important breeding season is influenced by the fishery, but also many environmental factors relating to recruitment of sandeel;
- Sandeel biomass and availability are generally considered to have a strong influence on kittiwake survival and breeding success;
- The evidence for common guillemot and razorbill links to forage fish is less clear, particularly in relation to east England colonies that are difficult to access to study;
- There are evidence gaps in terms of kittiwake diet and regional and temporal patterns of kittiwake prey types and quality in the UK. Hornsea Three has committed to funding kittiwake diet studies in order to fill these evidence gaps (see **Appendix A** for further information and the Applicant's contribution to further develop research to support government decision making for seabird conservation purposes);

- The management of prey resource (sandeel) could improve kittiwake productivity although evidence suggests that the relationship between the fishery, sandeels and seabirds is complex and also influenced by environmental factors;
- Environmental conditions are highly important for determining sandeel recruitment, biomass and ultimately prey availability and these are being impacted by warming seas;
- In order to increase sandeel availability to kittiwake, an ecosystem-based approach to fisheries management is likely to be highly important to due to complex trophic interactions and potential for top-down control;
- A number of evidence gaps currently exist (relevant to sandeel and kittiwake populations) which could make it difficult to predict, quantify or accurately match management actions to reported trends; and
- The same evidence gaps exist for the two auk species, but for the east England colonies the population trend has not meant that diet has been studied in the same way as it has been assumed that food shortage has not been a major constraint.

2 Delivery mechanisms

2.1 Introduction

2.1.1.1 In **Section 1** (Evidence review), the evidence for increasing kittiwake productivity through increased prey availability and specifically the availability of sandeel was reviewed. Though sandeel SSB has been linked to fishing mortality in the North Sea, the situation is complex and sandeel SSB is hugely variable, driven by large variability in recruitment year-to-year. This indicates that any reduction in fishing mortality with the ultimate goal of a lasting benefit to kittiwake (and guillemot and razorbill) cannot be scaled down due to large natural variance in stock recruitment and hence fishing mortality.

2.1.1.2 In this section, consideration is given to potential delivery mechanisms for enhancing prey availability and the feasibility of such measures. This section of this report considers the implementation requirements of increasing prey availability as compensation for kittiwake mortality. The discussion is set with the relevant legal and policy context and the requirements set out in EU guidance for the development of compensation measures. Possible compensation mechanisms within these categories are assessed for their technical, legal and political feasibility.

2.1.1.3 Part 2 (Delivery mechanisms) has been updated from a report produced for the Applicant by Howell Marine Consulting (Annex B) for Hornsea Three and was presented to NE, MMO and Defra at a workshop on 11 August 2020.

2.2 Developing compensation options

2.2.1 Overview

2.2.1.1 In 2016, Defra undertook a review of the effectiveness of Natura 2000 sites compensation measures in England[11]. Although this was focused mainly on replacing habitat, rather than compensating for a loss in species abundance, several conclusions in this report are useful in informing this work, most notably:

- *Each compensation scheme was influenced by a unique set of environmental and practical considerations and it is not possible to use any one case study as a model for future schemes.*
- *Ratios of compensation to loss above 1:1 reflect issues of uncertainty, and anticipated delays in the timescales which compensation habitat takes to develop replacement functionality.*
- *Objectives for compensation sites are highly case-specific and are not necessarily directly transferable to new projects.*
- *In the majority of cases there has been a lag between the loss of Natura 2000 habitat and the point where compensation measures have become functionally effective.*
- *Inter-seasonal variation in waterbird numbers means that it is extremely difficult to disentangle issues arising from habitat loss and replacement from natural variation.*

[11] Defra, "Review of the Effectiveness of Natura 2000 Sites Compensation Measures in England", 2016

- *There is considerable scope to improve consistency and transparency in advice and decision-making. This largely involves the need for a clear audit trail of the rationale for particular decisions, when and why they were taken.*
- *The case of compensation for Arcow Quarry highlights the risks to the integrity of the Natura 2000 network where compensation sites have not been formally designated[12].*
- *Where used, 'Regulators Groups' have proven to be an excellent way of ensuring ongoing dialogue between regulators and developers and establishing a process to track progress and sign off key stages. Standardised implementation of such an approach might help to avoid some of the historic problems identified in the report.*
- *Although there is ample guidance on how to create certain habitats, there is no clear distinction between general environmental improvement and the specific needs of compensatory habitat provision. A comprehensive yet simple report, setting out the relevant stages in objective setting, site selection and design, monitoring and reporting, could help to improve engagement with developers and to avoid confusion.*

2.2.1.2 EU guidance[13] sets out a range of options for developing compensation measures found in current practice in the EU under the Habitats Directive:

- species reintroduction;
- species recovery and reinforcement, including reinforcement of prey species;
- land purchase;
- rights acquisition;
- reserve creation (including strong restrictions in land use);
- incentives for certain economic activities that sustain key ecological functions; and
- reduction in (other) threats, usually to species, either through action on a single source or through co-ordinated action on all threat factors (e.g. factors stemming from space-crowded effects).

2.2.1.3 UK experience of compensation for marine impacts has been limited to coastal impacts, focused on intertidal areas, water birds and migratory fish. It is still the case that no substantive consideration has been given to compensatory measures in relation to seabirds or marine mammals. Some measures may be relevant as compensatory measures for offshore wind projects, for example reduction of impacts to nesting/roosting habitat for some seabirds through the creation of alternative sites[14]. These measures have been reviewed in **B2.7.1 PR Volume B2 Annex 7. 1 Compensation measures for FFC SPA Offshore Artificial Nesting Ecological Evidence**.

2.2.1.4 When looking at impacts on species that are causing increased mortality, such as those under consideration here, it is reasonable that two different approaches could be taken. The first is to decrease mortality in the rest of the population and the second is to increase productivity. Each approach, if successful, would have the net effect of increasing population numbers and offsetting any impact. Set out below are broad categories of

[12] Compensation land was owned by the developer and managed under a tenancy agreement by a third party. The former tenants have since purchased the land and should now be responsible for its management, but at the time of the report the mechanisms for securing appropriate management (s105 agreement and Higher-Level Stewardship Agreement) were not satisfactory.
[13] https://ec.europa.eu/environment/nature/natura2000/management/docs/art6/EN_art_6_guide_jun_2019.pdf
[14] ABPmer, (2020). UK Offshore Wind Expansion, Meeting the challenges of Article 6(4) of the Habitats Directive, ABPmer White Paper, January 2020.

measure that could fit under each approach, in line with current thinking for the Applicant and work recently undertaken on options for compensating impacts on seabirds due to offshore wind farms[15].

- Decrease mortality;
  - Predator control;
  - Reduce or remove pressure from collision risk; and
  - Reduce or remove pressure from fisheries by-catch.

- Increase productivity;
  - Reduce or remove pressures that increase mortality for sea bird prey resources;
  - Reduce or remove pressure on spawning grounds thereby increasing productivity of sea bird prey resources; and
  - Artificial nesting.

2.2.1.5 For this report, the focus is on increasing productivity by reducing or removing pressures that increase mortality on sea bird prey resources. For this option, ABPmer note that "*The removal/reduction of pressure on seabird prey species could provide benefit to seabirds but is likely to be difficult to demonstrate cause and effect, affecting confidence in the effectiveness of the measure*." The conclusion on the matter of demonstrating cause and effect is the subject of Part 1 (Evidence review).

2.2.1.6 In assessing different options, the following criteria were used. Each option is risk rated (red, amber, green) in line with the perceived confidence associated with the delivery of each criteria.

- Can a scientifically robust explanation be put together that shows success could be possible?
- Should the measure be in place for existing site management?
- Is the measure technically feasible?
  - Is it possible to practically implement the measure?
  - Will the measure be effective in meeting stated aims?
- Is the measure legally feasible?
  - Does the legal framework exist to support the measure?
  - Is there past legal precedent to support the measure?
- Is the measure politically feasible?
  - Is there political appetite to support the measure?
  - Does the current political climate make delivery of the measure harder or easier?

2.2.1.7 Where appropriate, commentary has also been made on the time that it would take to deliver a measure as well as potential financial costs. Following assessment of all options, it was noted that the first two criteria were consistently rated red or amber, mainly due to significant uncertainty. As such a discussion of these criteria in general has been brought forward to avoid duplication.

[15] ABPmer, (2020). UK Offshore Wind Expansion, Meeting the challenges of Article 6(4) of the Habitats Directive, ABPmer White Paper, January 2020.

2.2.2 Additionality

2.2.2.1 As mentioned previously, EC guidance[16] states that compensatory measures should be additional to the actions that are normal practice under the Habitats or Birds Directives, or obligations laid down in EU law. For example, the implementation of conservation measures under Article 6(1), or the proposal/designation of a new area already inventoried as being of community importance, constitute 'normal' measures for a Member State. Thus, compensatory measures should be distinct from the normal/standard measures required for the designation, protection and management of Natura 2000 sites. The reason for this is to ensure that SNCBs act in a proportionate way in line with the principles of Better Regulation and do not put their responsibilities for site management onto a third party through compensation.

2.2.2.2 The site improvement plan for the Flamborough and Filey Coast SPA [17] sets out that the target for kittiwakes is to restore the population above 83,700 breeding pairs from 51,535 pairs in 2017 (an increase of 62%). It also sets out that the top priority for the site is to investigate the cause of decline in the kittiwake population, which is said to be "probably due to reductions in sand eel abundance and changes to sea temperature". Work was planned from 2015 – 2020 on this, but it is not clear what the work comprised or whether this has been delivered yet.

2.2.2.3 Since 2015, Natural England have considered that prey availability is most probably the most significant issue associated with the decline in kittiwakes and that measures to increase prey availability could be the most important priority in restoring the kittiwake population as a measure for the management of the site. However, the Flamborough Head European Marine Site management plan[18] (consisting of Flamborough Head SAC and Flamborough and FIley Coast SPA) sets out that "international commercial fisheries, are not within the powers of the Relevant Authorities to manage", the relevant authorities including the MMO and Natural England. As set out in the section on managing fisheries in MPAs below, the powers of the MMO and Natural England with regards to fisheries only extend to 12 nm. However, since this point JNCC have produced joint guidance with the MMO on the revised approach to managing fisheries in MPAs, including those offshore which sets out the mechanism for doing this.

2.2.2.4 Any additional compensation measure taken by Ørsted, as the Applicant, in this matter will need to be carefully articulated to demonstrate additionality. If the number of kittiwakes that are deemed to be compensated for is set at, for example 700 (350 pairs), then this would account for an increase in 1% of the population that is required to be delivered by existing management measures. Setting out how this 1% increase is to be delivered outside of existing or planned management may be a challenge, not least because existing management measures have not yet been specified.

2.2.2.5 The reality is that when a site is newly designated, compensation measures may be the same as management measures, but should be seen as being in addition to them. For example, if a management measure for restoring a site's conservation objective for a

[16] EU Commission "Managing Natura 2000 sites the provisions of Article 6 of the Habitats Directive", 2018 update.
[17] http://publications.naturalengland.org.uk/publication/6404364100960256
[18] Flamborough Head European Marine Site Management Scheme 2016-2021

particular habitat is to recreate 10 km^2 of that habitat, it would be unreasonable to expect that 1 km^2 was delivered within the original amount as compensation. That 1 km^2 would need to be delivered additionally so the total amount delivered was 11 km^2. In this instance, as there is a clear priority to deliver a management measure to significantly improve the kittiwake population, any compensation measure should ideally use the same mechanism as the SNCB has already determined is the most appropriate for the site. In this case it is important for the SNCB to determine for themselves what the appropriate management measure is to inform understanding of what a potential compensation mechanism for the same purpose should be.

2.2.2.6 As a minimum, any approach should reinforce the close working required with SNCBs through Defra guidance, as the management measures for the site and the required compensation measures for the Applicant are, at the very least, extremely closely aligned.

2.3 Compensation options

2.3.1 Overview

2.3.1.1 The core aim of the compensation options that are examined in this paper is to increase the sandeel stock in SA1 within UK waters, although they are broadly applicable to sprat and herring as well. Though sandeel is the most important prey species of kittiwake during the breeding season at FFC SPA, the barriers are similar for the other main forage fish prey of kittiwake, including herring and sprat.

2.3.1.2 As already discussed in **Section 1.1.7**, there is considerable natural interannual variation in the sandeel stock in the North Sea which is overlaid on a declining trend due to climate change[19]. Reducing fishing mortality has the potential to increase sandeel stock biomass. Denmark is the main EU fishing nation for sandeel. In 2020 Danish quota was set at 215,863 metric tons, nearly double that set in 2019 (115,886 mt) with the UK granted almost 5,000t, and Sweden almost 8,000t. This fishery is largely run as a collaborative venture between the Danish Fishermen Producers Organization (DFPO) and the Danish Pelagic Producers Organization (DPPO). 2020's quota is worth an estimated DKK 417m, or £51 million, based on 2019 prices.

2.4 Fisheries management

2.4.1 Fisheries policy

2.4.1.1 Until the UK left the EU, fisheries were managed under the Common Fisheries Policy (CFP), although following EU Exit in December 2020, the UK has become an independent coastal state and will no longer be a formal part of the CFP. As negotiations continue, it is not yet clear the extent to which current access and quota arrangements will continue, which could range from a continuation of current practice to complete removal of all rights from EU vessels and redistribution of those rights to UK flagged vessels. As mentioned, ICES has signed an MoU with the UK government to provide scientific information and advice relating to the North Atlantic and its adjacent seas.

[19] http://www.mccip.org.uk/media/1818/mccip-sandeels-and-their-availability-as-prey.pdf

2.4.1.2 The UK will continue to be bound by the requirements of the UN Convention on the Law of the Sea (UNCLOS) and how this relates to the management of fisheries in any EU Exit outcome. This includes an obligation to co-operate with other coastal states on the management of shared stocks or stocks of associated species. In particular, coastal States have an obligation under UNCLOS to set an allowable catch and to grant other States EEZ fisheries access if (and only if) they do not have the capacity to harvest the entire allowable catch themselves (Article 62(2)). It is entirely reasonable for a coastal state to set the total allowable catch (TAC) at the capacity of their domestic fleet.

2.4.1.3 The House of Lords Inquiry into Brexit: Fisheries[20] concluded that a new fisheries management regime within the UK will only be effective if there is a degree of alignment to, and co-operation with, neighbouring states. Such regional co-operation will necessitate co-ordinated objectives and similar management practices, without which the sustainability of shared stocks, such as sandeel, may be undermined. They stressed that the UK should not discard the positive elements of the CFP that successive Governments have worked hard to achieve, such as sustainability and regional co-operation.

2.4.1.4 They also stated that unilateral restriction on access to fishing in the UK EEZ would almost certainly lead to reciprocal restrictions being placed on UK vessels fishing in the EU EEZ. This would also have a profound effect both on the fishing industry in the EU and on the UK fleet that relies on fishing outside the UK EEZ. Some form of mutual access arrangements must therefore be negotiated.

2.4.1.5 Defra have stated[21] that given the heavy reliance of the EU fishing industry on UK waters and the importance of EU waters to the UK it is in both the interests of the EU and the UK to reach a mutually beneficial deal that works for the UK and the EU's fishing communities.

2.4.1.6 In summary[22]:

- The UK will be seeking to move away from the CFP principle of relative stability[23] towards a fairer and more scientific method for future Total Allowable Catch (TAC) shares as a condition of future access.
- The UK will continue to apply the principle of Maximum Sustainable Yield (MSY) when setting or agreeing TACs and will promote fishing within MSY ranges in line with international scientific advice on mixed fisheries. The UK will also continue to work towards ending fish discards, including through the development of new initiatives with industry and other interests.
- The UK will seek to agree a process with the EU for future annual negotiations on access and fishing opportunities, as well as an approach for continued cooperation on fisheries management and on longer term sustainable approaches.

2.4.1.7 The overarching domestic policy directing UK fisheries is the Government's 25 Year Environment Plan[24] which aims to seize what is described as a once in a lifetime chance to

[20] http://www.parliament.uk/brexit-fisheries-inquiry
[21] http://www.parliament.uk/brexit-fisheries-inquiry
[22] Defra 2018 Innovative Technological Solutions for Sea Fisheries Control and Enforcement
[23] The principle of Relative Stability allocates a fixed share of fishing opportunities based on historical fishing patterns in 1973 - 1978
[24] https://www.gov.uk/government/publications/25-year-environment-plan

reform our agriculture and fisheries management, how we restore nature, and how we care for our land, our rivers and our seas. Specific commitments related to fisheries include:

- Implementing a sustainable fisheries policy as we leave the CFP;
- Ensuring that all fish stocks are recovered to and maintained at levels that can produce their maximum sustainable yield;
- Working with the devolved administrations as well as the UK fishing industry and other stakeholders to end wasteful discarding, putting in place the right incentives to ensure compliance, and collect data and use science in the policy decisions we make;
- Implementing science-based plans as part of our approach to managing fisheries sustainably and to recovering fish stocks to sustainable levels in the shortest time feasible;
- Upon leaving the EU, the Government will publish an annual statement on the state of fish stocks of interest to the UK; and
- Applying an ecosystem approach[25] to fisheries management that will account for, and seek to minimise, impacts on non-commercial species and the marine environment generally, including through technical conservation measures.

2.4.1.8 Now that the Fisheries Act (2020) is enshrined in UK law, the UK Government and Devolved Authorities will have to produce a Joint Fisheries Statement that will provide more detailed policy context than that within the current 25 Year Environment Plan. Notwithstanding this, the Fisheries Act does contain eight fisheries objectives which are:

- the sustainability objective;
- the precautionary objective;
- the ecosystem objective;
- the scientific evidence objective;
- the bycatch objective;
- the equal access objective;
- the national benefit objective; and
- the climate change objective.

2.4.1.9 These objectives give some guidance as to the importance of different factors guiding future fisheries management. It should be noted that the sustainability objective is the primary objective and sets out that:

1. *Fish and aquaculture activities do not compromise environmental sustainability in either the short or the long term;*
2. *Subject to point (1), fishing fleets must:*
   i. *be managed to achieve economic, social and employment benefits and contribute to the availability of food supplies, and*
   ii. *have fishing capacity that is economically viable but does not overexploit marine stocks.*

[25] an ecosystem approach to fisheries strives to balance diverse societal objectives, by taking account of the knowledge and uncertainties about biotic, abiotic and human components of ecosystems and their interactions and applying an integrated approach to fisheries within ecologically meaningful boundaries

2.4.2 Fisheries control

2.4.2.1 Across member states, the CFP uses a mixture of input and output measures to control and manage fisheries sustainably and it is likely that these measures will broadly continue post EU Exit. Output measures include plans, catch limits, quotas, and gear control. Input measures include controlling which vessels can access different areas of the sea, limiting the length of time at sea or number of vessels in a fleet able to go out to sea at any one time; and regulating the gears and methods fishermen use.

2.4.2.2 Output controls are mostly done through annual catch limits or TACs (Total Allowable Catches). The process for setting a TAC consists of scientific advice which is made up of national advice (in the UK from Cefas supported by Marine Scotland Science) and regional advice from ICES. This advice is then used in the Council of Ministers meeting every December (December Council) where TACs are then confirmed following political negotiation. TACs are then shared between EU countries in the form of national quotas based on the principle of relative stability which is a different allocation percentage per EU country that is fixed year on year. Multi-annual plans are in place as regionalised strategies to manage stocks on longer time frames and can include specific management objectives and measures.

2.4.2.3 TACs are designed to be set at the maximum sustainable yield for a population. This is a calculation of the harvesting yield which will result in at least 50% of a population still being viable at the end of a year, taking into account natural productivity and mortality (e.g. predation). While this calculation should take an ecosystem-based approach and account for linkages between prey species and quota species, in reality this is a very complex situation to understand and this is not often done.

2.4.2.4 Each Member State is responsible for allocating its quota share to its national fleet. In the UK, quota for each stock is split between devolved administrations according to the 2012 Concordat on Management Arrangements for Fishing Opportunities and Fishing Vessel Licensing [26]. It is then divided amongst the fleet via Fixed Quota Allocation (FQA) units. These are based on historic records and determine the proportions of quota for individuals or collective groups. In relation to buying quota, the Concordat Agreement in the UK governs the management of UK fish quotas. Rules have been developed pursuant to the Concordat concerning the methods by which relevant UK fish quotas are apportioned among UK fisheries administrations and administrative arrangements that will be operated on a UK basis.

2.4.2.5 In the UK, managers[27] also use technical measures and effort controls to manage both quota and non-quota stocks. The many kinds of technical measures include minimum landing or conservation sizes, specifications on design and use of fishing gear, and closed

[26] https://www.gov.uk/government/publications/concordat-on-management-arrangements-for-fishing-quotas-and-licensing-in-the-uk

[27] Defra is the government department responsible for UK fisheries policy and governance. Fisheries management is carried out by the devolved fisheries administrations: the Marine Management Organisation (MMO) in England, Marine Scotland in Scotland, DAERA in Northern Ireland, and the Welsh Government in Wales. Inshore fisheries are principally managed by regional bodies in England and Scotland (IFCAs and RIFGs, respectively), in contrast to Wales and Northern Ireland where a more centralised approach is taken.

areas or seasons[28,29]. These measures aim to improve selectivity in fisheries and reduce ecosystem impacts, and for quota species they can be used as an additional management measure, for example, some gears are better at selecting out species for which fishers have no quota, and these can be regulated. Technical measures are often used as the main management tool for non-quota shellfish and can differ according to devolved, national and EU regulations.

2.4.2.6 Fishing effort controls can be used on certain stocks to limit fishing capacity and vessel usage. For example, limits to the number of days at sea apply to some vessels targeting the quota species Dover sole in the western Channel. In general, however, the UK has a rights-based management system rather than an effort-based one.

2.4.2.7 Control and enforcement requirements for different fisheries management approaches are set out below:

- **Fisheries access** - This is one of the simplest requirements to understand. If a fisheries administration wants to put any type of management measure onto their fishery, they need to understand who is accessing that fishery, and to control that access. This requires some form of monitoring which can be based on the fishing vessel (e.g. VMS, iVMS, AIS); on earth observation (e.g. Synthetic Aperture Radar); on land (landings data); or through other forms of surveillance (at-sea surveillance, aerial surveillance).
- **Rights-based management** is typically difficult to monitor and enforce, but nevertheless is seen as being the most robust way to manage fisheries. In the UK system this is largely based around managing quota which is done through electronic logbooks, electronic landing data and electronic sales notes.
- **Effort based management** - Due to the limited effort-based management that exists in UK waters, any requirements around this area are themselves limited. The requirements that do exist, are largely met by a mixture of VMS and electronic logbooks which detail a vessel's location.

2.5 Spatial management

2.5.1 Overview

2.5.1.1 Work has already been undertaken for Ørsted by Howell Marine Consulting on managing the interaction between the fishing industry and offshore wind. This work principally looked at the construction and operation of an offshore wind farm within an area that is both designated for offshore wind, and where the ancient common law rights that the public has to fish in tidal waters (referred to as common law fishery rights) apply. This interaction happens frequently and is often not one that developers can avoid as they have to develop in government mandated areas that have often been designated within existing fishing grounds.

[28] https://www.gov.uk/government/publications/fishing-regulations-the-bluebook/section-e-technical-measures-for-the-conservation-of-fisheries-resources
[29] https://ec.europa.eu/fisheries/cfp/fishing_rules/technical_measures_en_105

2.5.1.2 It should be noted that the management approaches previously examined have been in the context of a future successful DCO application and deemed marine licence and were focused on managing the interaction between fishers and offshore wind during construction and operation, rather than in the context of compensatory measures under the Habitats Regulations. This is an important consideration as the measures were physically associated with an OWF site rather than further afield, as would be needed in the case of increasing prey availability. As such, measures such as closing the array to fishing would be unlikely to have any impact on populations of prey that live much further afield. Nevertheless, this previous work has shaped the understanding of some of the potential options in this report and there are some important conclusions to be taken from it, including:

- It is accepted practice that when managing coexistence between the fishing and renewable energy industries, fishing liaison officers should follow non-statutory guidance set out by the Fishing Liaison with Offshore Wind and Wet Renewables Group (FLOWW).
  - The Applicant outlined their approach to co-existence with fishermen within the Fisheries Coexistence and Liaison Plan. This sets out that as per the FLOWW (2014) and (2015) guidance, if co-existence is not possible, mitigation for disruption and displacement of fishing during construction is considered in the first instance with commercial compensation only being used as a last resort when there are significant residual impacts that cannot otherwise be mitigated.
  - The document makes clear that compensation should only be paid on the basis of factually accurate and justifiable claims. There is therefore an obligation upon affected fishers to provide evidence to corroborate any claims.
  - It should be noted that this guidance does not address compensatory measures under the Habitats Regulations. It also sets out that for the majority of matters, "it is for individual developers and the fishermen affected to reach a mutually agreeable position, using this guidance as a framework, during the project planning phase". The majority of such approaches have been successful, however, in a minority of cases, reaching such a mutually agreeable position with a diverse and numerous industry, and then maintaining that position throughout construction, and potentially operation, of a wind farm without having any statutory framework to fall back on can be challenging.
  - Other than BEIS approved Safety Zones, there are no current statutory means being utilised for prohibiting fishermen from entering an area where a particular type of fishing is not compatible with the survey, preconstruction, construction and operation of an offshore installation (it should be noted that it may be possible for a statutory instrument to be put in place as a regulation from the Fisheries Act).
  - From a legal perspective, it is important to understand that the current approach, one of balancing competing rights, is used as there are less enabling statutory powers offshore than there are onshore. For example, in order to compulsory acquire land onshore, the acquiring authority will rely

upon enabling statutory powers. Those enabling powers are not currently available offshore, hence the need to balance competing rights.

2.5.1.3 Any spatial management measure must also consider the issue of displacement. As set out in a report for Natural England, unless managed, displaced fishing effort can impact on the marine environment, within and outside MPAs, including on the seabed and benthic communities, mobile species and commercial fish and shellfish stocks. The net effect will depend on the balance between improvements within MPAs, and increased levels of effort in the remaining areas. Displacement can result in fishing disturbance being more widely distributed, including to otherwise previously unfished areas, and can cause localised increases in intensity and impact.

2.5.1.4 The effect of displacement on habitats and benthic communities depends on the sensitivity of the habitat where effort is displaced to, the gear type displaced, the level of fishing in the area prior to displacement and the relative change in fishing pressure compared to the baseline and to prevailing levels of natural disturbance. The net environmental outcome of protection of MPA features and impacts from displaced effort, for either site management or compensatory measures, is thus dependent on factors that vary on a case-by-case basis. If one is looking for an increase in abundance in a quota species both within and outside an MPA, then one must be sure that displacing fishing activity does not have a net zero effect on abundance.

2.5.1.5 In 2013, Defra introduced the Revised Approach, a structured approach for assessment and management of fishing activities in European Marine Sites (EMS) and latterly, Marine Conservation Zones, to ensure compliance with Article 6 of the EU Habitats Directive and the Marine and Coastal Access Act 2009 (MCAA). The process for spatial management of fisheries in relation to marine protected areas is set out in **Figure 2.1**.

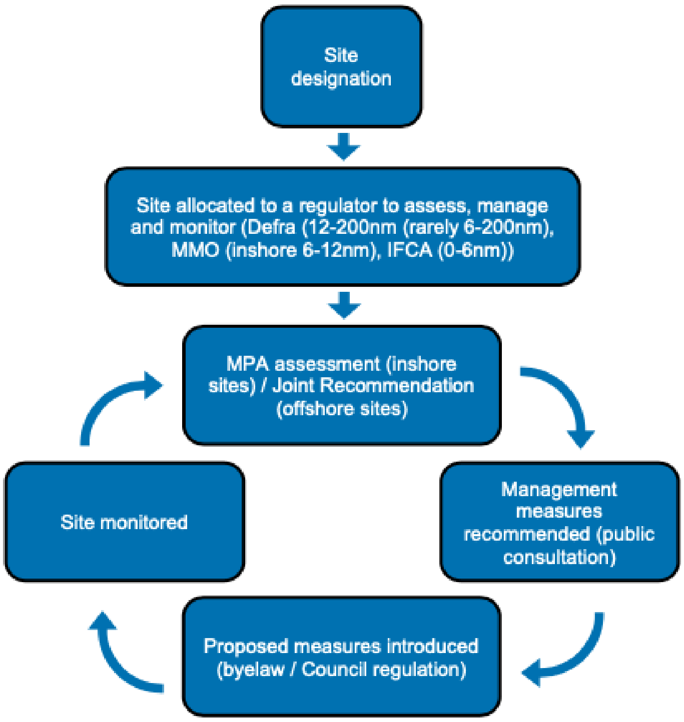

Figure 2.1 The process for spatial management of fisheries in relation to marine protected Areas

2.5.1.6 The options for spatial management include:

1. Fishing restriction order or byelaw.
2. European Commission delegated regulation establishing fisheries conservation measures for the protection of the marine environment.
3. Designation or extension of a new European marine site.

2.6 Fishing restriction order or byelaw

2.6.1.1 A fishing restriction order or byelaw can be implemented by the MMO or relevant IFCA under the Sea Fish (Conservation) Act 1967 as amended and the Marine and Coastal Access Act 2009.

2.6.1.2 Following EU Exit, fisheries in all UK waters are governed by the Fisheries Act which allows for the direct regulation of foreign fishing vessels in UK waters as well as provision to make regulations for a conservation purpose, which includes "the purpose of protecting the marine and aquatic environment from the effects of fishing or aquaculture, or of related activities". However, the EU and the UK have agreed on a transition period until June 2026 to switch from the current quota shares in UK waters to new quota shares.

,

2.6.1.3 Clause 38 of the Fisheries Act grants the MMO (and Scottish and Welsh Ministers) with increased powers to further regulate fisheries and the marine environment (Ares, 2020). Specifically of relevance here, it amends the MMO's byelaw-making powers outlined in the Marine and Coastal Access Act 2009, with an aim to reinforce consistency in the UK's approach to marine conservation.

2.6.1.4 The first evidence of these new powers was a consultation on draft assessments and management measures of fishing in four offshore MPAs opened in 2021[30]. These sites (Dogger Bank SAC, Inner Dowsing, Race Bank and North Ridge SAC, South Dorset MCZ, and The Canyons MCZ) are all designated for benthic habitats. Alongside a call for evidence from October to December 2020, MMO reviewed academic literature, fishing logbook, vessel monitoring system data and non-licensable activity data, to update and finalise site assessments and, where necessary, develop formal fisheries and marine non-licensable activity management proposals for these sites.

2.6.1.5 MMO then ran a formal consultation from February to March 2021 on the draft assessments and management measures proposed for the four offshore MPAs. Of relevance to Hornsea Four is the proposed management for adjacent MPAs, Dogger Bank SAC and Inner Dowsing, Race Bank and North Ridge SAC. The ecological consequences of this in relation to seabird species are discussed in **B2.7.1 Appendix F Population modelling of black-legged kittiwake on the English east coast to identify the population of first time breeders available to recruit to new colonies**.

2.6.1.6 In the current legal framework, measures could be put in place inside 12 nm in straightforward manner, and indeed this is a proven mechanism for managing impact on MPAs within 12 nm. However, there is still some uncertainty how the new powers granted through the Fisheries Act for measures offshore could be implemented and whether the wider political will and timescales are compatible with timely compensation. It was thought that via the old EC delegated regulation route the process would take in excess of five years and although it is likely to be much quicker now it could still be a lengthy process requiring substantial support from JNCC, MMO and Defra in order to proceed through the decision-making process.

2.6.1.7 With the passing of the Fisheries Act, the mechanism has been rescored from the Hornsea Three submission. Though the measure is more technically and legally feasible with the powers granted in the Fisheries Act, it is considered that it is less politically feasible currently given the range and significance of discussions already being had between Defra and the fishing sector around EU Exit.

Is the measure technically feasible?	
Is the measure legally feasible?	
Is the measure politically feasible?	

2.6.2 Designation or extension of a new Marine Protected Area

2.6.2.1 Designation or extension of a new MPA would still require additional fisheries management measures to be put in place as set out previously, either through the HRA process or through site management measures and would not technically achieve the desired aim on its own. The process for designation or extension of a new MPA is lengthy (>2-3 years) and requires significant consultation under either domestic or EU legislation.

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

2.6.2.2 An additional designation would add weight to any specific area that is considered important but as the main area for the sandeel fishery is Dogger Bank, which is already designated, and has restrictions in place, any additional weight may be insignificant.

Is the measure technically feasible?	
Is the measure legally feasible?	
Is the measure politically feasible?	

2.7 Quota management

2.7.1.1 Whereas spatial management measures have challenges in managing the impact of displacement such that the total biomass of sandeel caught does not actually reduce, due to increased take outside the spatially managed area, reducing the overall TAC would increase the total biomass of sandeel by directly reducing total fishing pressure in the North Sea. The process by which quota is set has been discussed previously, but in simple terms can be broken into two stages as set out in **Figure 2.2**.

2.7.1.2 ICES has signed an MoU with UK government to provide the UK with scientific information and advice relating to the North Atlantic and its adjacent seas. The EU and the UK have agreed on a transition period until June 2026 to switch from the current quota shares and this process will likely change before then.

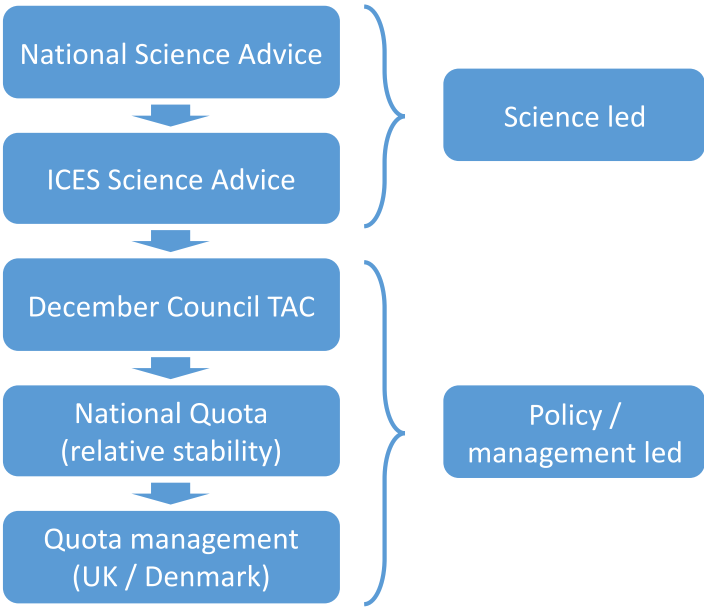

Figure 2.2 Process of setting quota through the CFP

2.7.1.3 The first part of this process consists of science advice given firstly by national science bodies (Cefas, supported by Marine Scotland Science, Natural England and JNCC) to ICES and then from ICES to December Council and can be thought of as science led and independent of political influence. The second part of this process consists of negotiations between member states and then management of allocated quota at a national level which is subject to political decision making albeit within the constraints of the relevant enabling legislation which sets certain boundaries with regards to good governance.

2.7.2 Science led approach

2.7.2.1 A science-led approach is predicated upon close working with national science bodies (Cefas and Marine Scotland Science) and ICES, in collaboration with Natural England and JNCC, to improve the stock assessment model for forage fish such that it takes a full ecosystem-based approach to managing forage fish stocks. This would need to predict the sandeel biomass required to maintain the kittiwake population at an acceptable level and include this in a stock assessment model within the predation parameter. This could then feed into the overall calculation of MSY and effectively baseline a proportion of the sandeel biomass to maintain the kittiwake population.

2.7.2.2 This approach is undoubtedly much more complicated to carry out in practice and requires effective and complex ecosystem models, an understanding of the predator prey dynamics for different bird and sandeel populations and broad agreement within the fisheries science community to be successful.

2.7.2.3 This approach could potentially have a significant impact on restoring kittiwake populations within the SPA, in line with published management measures, much larger than the additional 1% increase in population that was assumed as a reasonable compensatory amount earlier in this paper.

2.7.2.4 A clear advantage of this approach is that it could permanently "ring fence" sandeel biomass for kittiwake consumption at the point of stock assessment and ICES advice. Sandeel Area 1r is the stock area adjacent to FFC SPA and relevant to foraging kittiwake. Since 1983, the total catch of sandeel in Area 1r has varied dramatically. From year to year, it is not uncommon for the TAC to double and, notwithstanding years when the fishery was shut apart from monitoring, the total catch has ranged from a minimum of 46,116 tonnes (2012) to a maximum of 610,123 tonnes (2002). Were rights acquisition via commercial agreement possible it could simply result in a change to quota advice the following year resulting in no net increase in the availability of sandeel prey to kittiwake.

2.7.2.5 Although the UK is no longer be part of the CFP, the stock assessment process will remain the same. ICES has signed an MoU with UK government to provide the UK with scientific information and advice relating to the North Atlantic and its adjacent seas. The EU and the UK have agreed on a transition period until June 2026 to switch from the current quota shares and this process will likely change before then.

2.7.2.6 As such this option has the benefit of being both outside the political process, which will undoubtedly be challenging in the short term (1-3 years), and to have some stability of approach in the future. The main question around this approach is whether it can be secured within the relevant timeframes as it is likely to take between 3-5 years to have full traction. The cost of implementing this approach is largely centred on the research required to produce effective ecosystem models.

Is the measure technically feasible?	

Is the measure legally feasible?	
Is the measure politically feasible?	

2.7.3 Policy / management led approach

2.7.3.1 The policy / management led approach is predicated upon either influencing the decision making at the EU Agriculture and Fisheries Council such that a TAC is set below the advice given by ICES to take into account the additional biomass needed, or that national agreement on the allocation of quota is made such that quota is withheld to the same end.

2.7.3.2 It would be very unusual for December Council to set TAC below the advice given by ICES, indeed in 2018 Fisheries ministers set 41% (45 of 110) of the TACs exceeding scientific advice and the remaining 51% were in line with scientific advice. Any precautionary setting of TACs is always done on the basis of scientific advice rather than through unilateral decision making for other reasons. This is reasonable and is line with the objective to sustainably exploit a fishery for economic gain. Indeed, in the debate on the Fisheries Bill in 2018, George Eustice, current Defra Secretary of State but at the time Minister of State with responsibility for fisheries in Defra, stated in relation to this matter:

- "Sandeel stock is the most important access that Denmark receives from the UK, so we will have to consider it in the context of our annual fisheries exchanges";
- "The issue with a unilateral ban on the fishing of all sand eels in all UK waters is that we would be likely simply to displace that fishing activity, so there would be unsustainable catches of sand eels in waters outside the UK EEZ."; and
- "Given the way ICES advice is generated, based as it is on maximum sustainable yield, it tends not to place great weight on such considerations [an ecosystem based approach to stock assessment], but there is no reason why, in the context of future UK-EU bilateral negotiations, we should not seek to argue that there should be more restraint on species such as sand eels where they have an important role as a food source for birds."

2.7.3.3 This is a matter that has had consideration at the highest levels of UK government and whilst broad support has been shown to resolve it, it is accepted that this cannot be done unilaterally at the current moment in time. This is also in the context of more than 100 fish stocks in the Atlantic and North Sea that have been co-managed between EU-UK during the last decades.

2.7.3.4 Withholding quota at a national level is possible, but would need strong cooperation from the managing authorities, which at the moment include the Danish and UK governments, but post EU Exit would be just the UK government. The MMO currently reserves the right to retain quota centrally for other purposes such as to clear certain overfishes or meet other policy objectives, for example when trialling new management approaches such as gear restrictions or remote electronic monitoring system. It is possible, though not certain, that the MMO may be able to withhold quota for the Danish sandeel fleet following any transitional quota agreement.

2.7.3.5 Any option would have significant uncertainty around it and would require robust cooperation from national governments and fisheries managing authorities, potentially in both Denmark and the UK, at a time when international negotiations are particularly sensitive. There would need to be careful articulation and understanding of why quota should be withheld above and beyond either the scientific advice or the TAC agreed at the EU Agriculture and Fisheries Council which nominally sets the maximum sustainable yield and should be based upon an ecosystem approach.

2.7.3.6 At the December Council 2020, provisional quotas were set with the intention of ensuring the continuation of sustainable fishing in the concerned areas until consultations with the UK are concluded. The provisional quotas include a proportionate roll-over of the existing 2020 fishing opportunities for the first three months of 2021 (applying a 25% ratio of the total existing Union quota).

2.7.3.7 It is unlikely that any such approach could be brought to bear at this time given the ongoing EU-UK negotiations of 100 previously co-managed stocks and the political sensitivities that surround fisheries in particular.

Is the measure technically feasible?	
Is the measure legally feasible?	
Is the measure politically feasible?	

2.8 Rights acquisition

2.8.1.1 The acquisition of rights to secure compensation is relatively common in terrestrial HRA, particularly with regard to agricultural practice or land rights. In this instance the acquisition of rights via commercial agreement would relate to buying a proportion of the fixed quota allocation (FQA) from one of the parties that owns it. This would most likely be the Danish Producer Organisation (PO) as the proportion owned by UK fisheries is so small (8000 t for 2020).

2.8.1.2 The EU CFP permits trading of quota between Member States and while this trading is administered by the relevant Fisheries Administrations, in practice the trading operates between POs and the equivalent organisations in other Member States. A similar situation applies within the UK where, after 1996, rules on quota trade between POs became more flexible and POs were allowed to make quota "gifts" (i.e. with no reciprocal transfer of quota, which had previously been required). This made it much easier for a vessel in one PO to lease quota from a vessel in another PO. Under the current FQA system, however, no permanent adjustments of vessels' FQAs are permitted.

2.8.1.3 However, the rules implementing the Concordat Agreement do not provide a mechanism for a non-fishing related organisation to purchase or lease the quota. It would be contrary to the objective of setting quota to ensure sustainability of fisheries for a non-fishing related organisation to then purchase that quota to achieve an alternative objective. Ørsted is of the view that it would not only contravene current fisheries policy but is unethical.

2.8.1.4 Denmark uses a system of Individual Transferable Quota (ITQ) in conjunction with measures to prevent the concentration of quota ownership and protect coastal fishermen.

Quotas come in the form of tradable rights held by active fishermen and attached to vessels. These rights come in the form of a share of the national quota. They can be freely leased and swapped within Fishpool groups that facilitate transactions. Permanent trades of quotas can also be performed under the authorisation of the ministry. In order to keep quota ownership in fishermen' hands, only active fishermen can hold quota and any company holders must be two-thirds owned by fishermen. Additionally, any individual operator cannot hold more than 10% of the quota for demersal stocks. Under the current quota regulations, the purchase of quota by an offshore developer is not a viable proposal.

2.8.1.5 For reasons already discussed around removing quota allocation that is based upon science advice that has supposedly set the maximum sustainable yield for a fishery, it is unlikely that a third party who is not in the fishing industry would be permitted by a relevant Fisheries Administration to purchase quota for the purpose of setting it aside. In addition to this, the quota allocation for 2020 is worth £51 million, and even a small percentage contribution to this equates to a significant ongoing financial liability that would be prohibitive.

2.8.1.6 Furthermore, it is anticipated that fisheries organisations would, by default, position themselves against quota purchase as in effect this is a measure that results in a reduction in fishing opportunities. In this context it is important to note that the allocation of quota in many cases takes account of the track record of the fishery; a reduction in landings as a result of a developer buying quota would result in changes in the amount of quota that is allocated to a given fleet in the following years. Where quota is not fished, the excess may end up being allocated to another fleet segment or to another member state.

Is the measure technically feasible?	
Is the measure legally feasible?	
Is the measure politically feasible?	

2.9 Commercial agreement

2.9.1.1 Commercial agreements have previously been used as a short-term arrangement during construction operations for offshore wind farms. The purpose would be to restrict where the fishermen operate, though would not prevent unknown fishermen fishing in an area. Various project companies within the Ørsted group have entered into commercial agreements with local fishermen to compensate for not fishing within defined areas as a temporary measure. The areas are defined pursuant to rights granted by The Crown Estate in an Agreement for Lease or Lease granted to the project company. The commercial agreement is for specific periods of time during pre-construction and construction works. Ørsted has not, to date, entered into commercial agreements with fishermen to restrict fishing activity during the operational lifetime of a windfarm in the UK. Ørsted Hornsea Project Three (UK) Limited can only negotiate commercial agreement to restrict the movement of fishermen within our Agreement for Lease area because the Crown Estate has demised the Rights to Ørsted Hornsea Project Three (UK) Limited.

2.9.1.2 There have been several issues associated with these commercial agreements including:

- There are limited statutory means of ensuring compliance with any arrangements, which can lead to fishermen asking for changed terms at very short notice.
- There have previously been few dispute resolution mechanisms employed, other than action through the High Court.
- For offshore wind developers, reaching a mutually agreeable position with a very diverse and numerous fishing industry, and then maintaining that position throughout the operation of a wind farm without having any statutory framework to fall back on is very challenging. Even though developers look to enter into binding commercial agreements, the lack of a statutory framework can cause difficulties.
- It is considered that to manage the interaction between fisheries and offshore wind construction and development the following is needed, much of which does not exist in state or regulation, but which is left to the High Court to deliberate on:
    1. A statutory mechanism for fairly and openly compensating fisheries vessels for any loss of earnings.
    2. A statutory mechanism for managing and enforcing the movement of fisheries vessels in an area held under a lease or agreement for lease from the Crown Estate for development of an offshore wind farm.
    3. A mechanism for dispute resolution.
    4. A means of ensuring that the regulatory process can be administered in a cost-effective way.

2.9.1.3 Ørsted have tried to find alternative means of dispute resolution if agreement cannot be reached or if the fisherman breaches an existing agreement but the only action available is injunctive proceedings. The fishermen are not incentivised to engage in alternative dispute resolution. Applying for an injunction is a costly and time-consuming process. It is also draconian as a breach of an injunction can result in committal proceedings. Ørsted has also investigated whether there are other statutory mechanisms available to safeguard a site from fishing vessels during pre-construction surveys and during construction and concluded after extensive engagement with stakeholders, including the MMO, BEIS and the MCA that there are no satisfactory statutory mechanisms available outside of territorial waters.

2.9.1.4 A commercial agreement could not prevent unknown fishermen from operating within the array and it would also not prevent the reallocation of quota at a future date. If a producer organisation does not catch their quota allocation over a three-year period, then that quota would simply be reallocated. In addition to this, restricting fishing within the array would not preclude the fishermen from finding alternative grounds in order to catch their quota.

2.9.1.5 Finally, the quota allocation for 2020 is worth £51 million, and even a small percentage contribution to this equates to a significant ongoing financial liability that would be prohibitive. For these reasons, this is not a preferred mechanism.

Is the measure technically feasible?	(red)
Is the measure legally feasible?	(green)
Is the measure politically feasible?	(amber)

2.10 Summary of findings

2.10.1.1 None of the measures considered within this paper are simple to deliver as can be seen from Table 2.1, which presents an initial summary of the review undertaken in Section 2 (Delivery mechanisms).

2.10.1.2 All have some measure of technical difficulty and most have some measure of political challenge associated with them. All measures, apart from a commercial agreement, would need significant support from Defra, MMO, JNCC, Natural England and in some cases the Danish Government, as well as significant engagement and interaction with the Danish sandeel fishing industry.

2.10.1.3 In addition to the challenges set out above, uncertainty remains over the scientific robustness of any measures associated with prey availability on the kittiwake population at the Flamborough and Filey Coast SPA and even more uncertainty in relation to guillemot and razorbill. It would also be interesting to understand the progress that Natural England have made in exploring prey availability in relation to the management of the site as set out in the Site Improvement Plan. Any progress that has been made in this regard, or indeed any views that Natural England may have on the best approach to measures required for restoration of the kittiwake population in relation to site management would be pertinent to any potential compensatory measure.

Table 2.1 Summary of findings for measures considered

	Fishing restriction order / Byelaw	Designation / Extension of new MPA	Science led approach to quota allocation	Policy / management led approach to quota allocation	Rights acquisition	Commercial agreement
Is the measure technically feasible?						
Is the measure legally feasible?						
Is the measure politically feasible?						

2.11 Conclusions

2.11.1.1 Based upon this review of mechanisms, Ørsted advocate the need for a science-led and ecosystem-based assessment of predicted mortality to understand the predation rate needed to feed into the maximum sustainable yield calculation. Any commercial agreement with the DFPO and the DPPO, by way of example, would not serve any purpose until as a first step, an effective ecosystem model is deployed to “ring fence” any increase in sandeel for kittiwake consumption. This is pertinent to any North Sea forage fish prey of kittiwake, razorbill and guillemot. Thus, a government-led approach to sustainable management of forage fish fisheries seems the only feasible proposition for long-term measure addressing prey availability.

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Appendix A : Ørsted's Strategic Compensation Approach

1 Overview

1.1.1.1 Orsted Hornsea Four UK Limited (the Applicant) has put together a robust without prejudice derogation case for four seabird species, which will be the first such case presented as part of an offshore wind farm project application. As part of the evidence development process to support this novel approach, the Applicant has worked collaboratively with subject matter experts including academics, consultants and delivery partners to gather information which, beyond the project specific use, will benefit the wider offshore wind industry and support broader understanding about the functioning of species and habitats within the National Site Network.

1.1.1.2 The Applicant's wider group, herein referred to as Ørsted, acknowledges the complexity and connectivity of the UK's Marine Protected Areas network, and therefore supports a joined up approach to marine compensation which supports the UK's net zero ambitions in an ecologically coherent manner.

1.1.1.3 This document provides a brief overview of how the Applicant's compensation related work is supported by a wider, industry scale approach, and is intended to provide reassurance to the Secretary of State of Ørsted's commitment to develop a strategic approach to address the availability and efficacy of compensatory measures.

2 Stakeholder background

1.1.1.4 During Ørsted's consultation, marine stakeholders, including Natural England and The Wildlife Trusts, have advised that a strategic approach to delivery of compensation is supported, particularly in relation to mechanisms to increase prey availability to protected seabird species. In their consultation response to Hornsea Project Three[31], Natural England 'acknowledge that certain mechanisms related to increasing prey availability, specifically sandeel, might require a Government led and/or strategic response'. TWT[32] in their response to the Applicant's compensation consultation state that the 'exploration of strategic compensation measures' is needed, indicate a preference for 'the implementation of fisheries management measures' and also state that 'the removal of fisheries pressure will have one of the biggest impacts in providing environmental headroom for further development'. To ensure the best possible outcomes for the marine environment, Defra[33] is currently seeking feedback on how to address the cumulative impacts of marine activities on the environment and how compensatory measures might be delivered at a greater scale than for individual projects.

3 Ørsted's Environmental Research

1.1.1.5 The Ørsted R&D Environment Programme aims to identify key global offshore environmental consenting risks in order to decarbonise global energy systems and stop global warming at 1.5°C in balance with nature. By taking a global view, it allows Ørsted to learn from experiences in other regions and form a view of best practice. Ørsted works with

[31] Natural England, pg 14 (2 November 2020). Available on the Planning Inspectorate's Hornsea Three portal.
[32] The Wildlife Trusts, pg 3 (6 September 2021). Available in Hornsea Four's consultation summary.
[33] Defra, 2021: MPA compensation guidance consultation. Accessed at: https://consult.defra.gov.uk/offshore-wind-and-noise/mpa-compensation-guidance-consultation/ 24/09/2021

leading universities around the world in order to deliver high quality environmental research. This research contributes towards delivering Ørsted's target that all renewable energy projects commissioned will have a net-positive impact on biodiversity by 2030 at the latest.

1.1.1.6 With direct relevance to UK seabirds and independent of wind farm specific commitments, Ørsted has committed £800,000 for the three year PREDICT project[34] (*Predicting seasonal movement of marine top predators using fish migration routes and autonomous platforms*), which is a collaboration between the University of Aberdeen and the University of the Highlands and Islands Environmental Research Institute. This research aims to better understand the ecological mechanisms that make fish available as prey to seabirds, as well as investigating next-generation technologies for hydroacoustic and coordinated measurement. This research may support spatial decisions on where new wind farms are located, as well as better informing management of prey species for conservation purposes by the UK government.

4 Hornsea Three's Contribution

1.1.1.7 Beyond the project's compensation related DCO requirements, Hornsea Three have committed to deliver research, in collaboration with Defra, on kittiwake diets during the breeding season and assessing the current and future condition of fish prey populations to inform an ecosystem based assessment of prey availability to kittiwake. These studies were identified by the Offshore Wind Strategic Monitoring Research Forum (OWSMRF) which is an industry-led collaborative forum that aims to better understand the impact of large-scale offshore wind development on marine birds. The Key Stakeholders include Natural England, NatureScot, Natural Resources Wales, Department of Agriculture, Environment & Rural Affairs (DAERA), Royal Society for the Protection of Birds (RSPB) and Marine Scotland Science.

1.1.1.8 The JNCC organised a workshop of experts that aimed to identify research opportunities that will improve understanding of kittiwake population dynamics and drivers of population change in the context of offshore wind development, thereby improving our ability to predict population response to novel impacts. The resulting report provided a summary of existing evidence followed by research opportunities suggested by experts to fill gaps in our current

Kittiwake diets during the breeding season, and the relationship between prey availability and productivity

This project is a combination of desk-based and field studies to determine kittiwake dietary patterns on the English east coast during the breeding season and improve our understanding of the relationship between non-sandeel prey availability and productivity. This research will help build confidence in how kittiwake populations are responding to declines in sandeel availability and thus assess their resilience to additional mortality. This would also provide key evidence to inform conservation measures, such as how kittiwake populations might respond to changes in management of commercial fisheries.

[34] University of Aberdeen (13 September 2021), PREDICT project to find better ways of protecting our oceans. Accessed at: https://www.abdn.ac.uk/news/15309/ 24/09/2021

Assessing the current and future condition of alternative fish prey populations: a desk-based study

With this research, it is proposed to review the literature on forage fish species, specifically population status and trends, drivers of population dynamics, current fishing pressure and projected impacts of climate change on forage fish populations. This information will assist with identifying kittiwake colonies that are vulnerable to additional mortality and those that are likely to be more resilient to additional mortality, e.g. from OWF development, due to predicted availability of prey/forage fish species. Additionally, this will help assess which conservation management measures may be ineffective due to changes in forage fish populations.

understanding of kittiwake population dynamics in the context of offshore wind development[35]. Two of the research opportunities were developed and committed to by Hornsea Three with the intention that they support inter-agency government decision making. A summary of the research being taken forward by Hornsea Three is included in the text boxes above.

5 Hornsea Four's contribution

1.1.1.9 As detailed within **B2.6.2 RP Volume B2 6.2 Compensation Measures for FFC SPA Prey Resource Evidence**, there is no available means by which an individual developer can secure fisheries management in a legal and proportionate manner. However, the Applicant understands the importance of the predator/prey relationship for seabirds, and therefore is committing £500,000 over 5 years to further develop research to support government decision making for seabird conservation purposes. Hornsea Project Three's contribution is targeted towards kittiwake, and therefore it is proposed that the Applicant's proposed fund targets the prey relationship with razorbill and guillemot, and/or supports field data collection in line with the methodologies developed as part of the PREDICT project. There is also the potential to investigate the location of key foraging areas (e.g. oceanic fronts with high associated productivity of forage fish) and their temporal and spatial variability using unmanned vessels with echosounders, which could build on research being taken forward as part of Ørsted's wider research and development program.

1.1.1.10 The potential research projects that the Applicant could contribute towards are:

1. Guillemot and razorbill diets during the breeding season, and the relationship between prey availability and productivity.
2. Assessing the current and future condition of alternative fish prey populations for guillemot and razorbill (building on what Hornsea Three are doing).
3. Investigating the location of key foraging areas for the FFC SPA colony and their temporal and spatial variability.

[35] Black-legged kittiwake population dynamics and drivers of population change in the context of offshore wind development (JNCC Report No. 651)

1.1.1.11 The Applicant has requested guidance from the relevant statutory advisors on the specifics of any future research questions, and consultation on these proposals will continue prior to the commencement of the Applicant's Examination.

6 Guidance development

1.1.1.12 Ørsted's UK Environment and Consents Stakeholder team have run a series of knowledge development sessions with key government stakeholders, including BEIS and Defra, focussing on the practicalities and challenges of delivering compensation for species and habitats in the marine environment. Ørsted's experience of Hornsea Three's DCO process and the post-consent discharge of compensation related DCO conditions has led to some useful insights for government and industry.

1.1.1.13 In July 2022, Defra opened a consultation process on their draft best practice guidance for developing compensatory measures in relation to Marine Protected Areas (MPAs), acknowledging that there is a need for further guidance on the interpretation of current EU Commission Guidance (Managing Natura 2000 (2018)) for UK projects which interact with MPAs. Ørsted, as well as a number of industry groups which Ørsted participate in, are inputting a response. There are a number of matters within the guidance which are pertinent to the Applicant's context:

- Hierarchical approach: It is appropriate to target compensatory measures for the species impacted, within or outside the affected designated site.
- Location approach: It is appropriate to provide compensation outside of the affected designated site, where it is not possible to deliver within the site.
- Ratio approach: Compensation should be provided at a ratio at or above 1:1.

1.1.1.14 As part of this consultation, Defra is also seeking views on the development of compensation in a strategic manner. Ørsted is supportive of a strategic approach to compensation delivery and is leading a solution-focussed approach to this in collaboration with regulators and other key interested parties.

7 Developer Collaboration

1.1.1.15 Over the summer of 2021, Ørsted reached out to other offshore wind developers to understand the level of interest in the industry leading a collaborative approach to strategic compensation and received a positive response from all industry representatives. Ørsted is currently leading this collaboration of offshore wind operators and developers to promote a strategic approach to the delivery and securing of compensation. The collaboration is currently hosted under the Offshore Wind Industry Council's Developer Group, and a series of workshops involving regulators, statutory nature conservation bodies and devolved administrations are planned for Q4 2021.

1.1.1.16 While Ørsted supports strategic delivery of ecological compensation, it is not in any way the intention for project specific plans which are already significantly developed, such as those presented for the Applicant, to be replaced by compensation delivered on a strategic scale. This is necessarily due to the very early stage of the strategic proposals. Nevertheless, any future research or monitoring results delivered through a strategic scheme may support the wider-scale evidence development process for compensatory measures proposed by the Applicant and may support the adoption and design of any potential adaptive management if required.

8 Summary

1.1.1.17 This note provides an overview of how Ørsted's support of a long-term evidence process, including the delivery of strategic compensation, supports the Applicant's proposals, and details the Applicant's commitment to better informing prey management for seabird conservation purposes by funding research. Ørsted's leading role in strategic compensation discussions provides reassurance to the Secretary of State as to the long-term and research focussed approach which underpins the Applicant's proposals.