Outer Dowsing Offshore Wind

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Table of Contents

List of tables

Abbreviations

Acronym	Expanded name
ACAP	Agreement on the Conservation of Albatrosses and Petrels
BEIS	Department for Business, Energy & Industrial Strategy (now the Department for Energy Security and Net Zero (DESNZ))
Cefas	Centre for Environment, Fisheries and Aquaculture Science
CIMP	Compensation Implementation and Monitoring Plan
DCO	Development Consent Order
DESNZ	Department for Energy Security and Net Zero, formerly Department of Business, Energy and Industrial Strategy (BEIS), which was previously Department of Energy & Climate Change (DECC)
EEZ	European Economic Zone
EU	European Union
FFC	Flamborough and Filey Coast
GT R4 Ltd	The Applicant. The special project vehicle created in partnership between Corio Generation (a wholly owned Green Investment Group portfolio company), Gulf Energy Development and TotalEnergies
ICES	International Council for the Exploration of the Sea
IFCA	Inshore Fisheries & Conservation Authorities
JNCC	Joint Nature Conservation Committee
LEB	Looming Eye Buoy
LED	Light-emitting diode
MMO	Marine Management Organisation
MRF	Marine Recovery Fund
NFFO	National Federation of Fishermen's Organisations
NSIP	Nationally Significant Infrastructure Project
ODOW	Outer Dowsing Offshore Wind (The Project)
OOEG	Offshore Ornithology Engagement Group

Acronym	Expanded name
OWF	Offshore Wind Farm
RIAA	Report to Inform Appropriate Assessment
RSPB	Royal Society of the Protection of Birds
SBWG	Seabird Bycatch Working Group
SNCB	Statutory Nature Conservation Body
SoS	Secretary of State
SPA	Special Protection Area
UV	Ultraviolet

Terminology

Term	Definition
Array area	The area offshore within the PEIR Boundary within which the generating stations (including wind turbine generators (WTG) and inter array cables), offshore accommodation platforms, offshore transformer substations and associated cabling are positioned.
Baseline	The status of the environment at the time of assessment without the development in place.
Development Consent Order (DCO)	An order made under the Planning Act 2008 granting development consent for a Nationally Significant Infrastructure Project (NSIP) from the Secretary of State (SoS) for Department for Energy Security and Net Zero (DESNZ).
Effect	Term used to express the consequence of an impact. The significance of an effect is determined by correlating the magnitude of an impact with the sensitivity of a receptor, in accordance with defined significance criteria.
Impact	An impact to the receiving environment is defined as any change to its baseline condition, either adverse or beneficial.
Landfall	The location at the land-sea interface where the offshore export cable will come ashore.
Mitigation	Mitigation measures, or commitments, are commitments made by the Project to reduce and/or eliminate the potential for significant effects to arise as a result of the Project. Mitigation measures can be embedded (part of the project design) or secondarily added to reduce impacts in the case of potentially significant effects.
Outer Dowsing Offshore Wind	The Project
Onshore Infrastructure	The combined name for all onshore infrastructure associated with the Project from landfall to grid connection.
The Applicant	GT R4 Ltd. The Applicant making the application for a DCO. The Applicant is GT R4 Limited (a joint venture between Corio Generation, TotalEnergies and Gulf Energy Development (GULF)), trading as Outer Dowsing Offshore Wind. The project is being

Term	Definition
	developed by Corio Generation (a wholly owned Green Investment Group portfolio company), TotalEnergies and GULF.
The Project	Outer Dowsing Offshore Wind including proposed onshore and offshore infrastructure.
Wind turbine generator (WTG)	All the components of a wind turbine, including the tower, nacelle, and rotor.

1 Summary

1.1 Background

1.1.1 This report provides a review of the evidence of the potential for bycatch mitigation measures to increase the annual recruitment of northern gannet, *Morus bassanus* (hereafter gannet), common guillemot, *Uria aalge* (hereafter 'guillemot'), and razorbill, *Alca torda,* in addition to a variety of other species into the regional population of the southern North Sea. The report also lays out mitigation options and roadmap for the delivery of this 'without prejudice' compensation measure for impacts to the Flamborough and Filey Coast (FFC) Special Protection Area (SPA), in relation to the potential impacts of Outer Dowsing Offshore Wind (the Project).

1.1.2 The draft Report to Inform Appropriate Assessment (RIAA; Document 7.1) has concluded that there would be no Adverse Effect on Integrity (AEoI) to the FFC SPA for guillemot and razorbill. Without prejudice compensation has been developed for these species in response to stakeholder concerns.

1.2 Key findings

1.2.1 Potential bycatch mitigation measures relating to longline fisheries (considered relevant for gannet), and gillnet fisheries (considered relevant for guillemot and razorbill) are presented, alongside available ecological evidence on their potential effectiveness as a compensation measure.

1.2.2 For longline fisheries, a shortlist was created which included Lumo Leads, Side setting with bird scaring lines, night setting, Scary bird and hook shielding. These measures are reported to be effective at reducing seabird bycatch, with no recorded negative impacts on fisheries.

1.2.3 For gillnet fisheries, net illumination, visual net modifications (reflective nets and high visibility nets) and above water deterrents were shortlisted, also reported to be effective measures with no recorded negative impacts on fisheries.

2 Introduction

2.1 Project background

2.1.1 GT R4 Limited (trading as Outer Dowsing Offshore Wind) hereafter referred to as the 'Applicant', is proposing to develop the Project. The Project will be located approximately 54km from the Lincolnshire coastline in the southern North Sea. The Project will include both offshore and onshore infrastructure including an offshore generating station (windfarm), export cables to landfall, and connection to the electricity transmission network (see Volume 1, Chapter 3: Project Description for full details).

2.2 Document purpose

2.2.1 The draft RIAA undertaken for the Project has not identified any impacts on gannet, guillemot or razorbill, however this report aims to support the identification of potential ‘without prejudice’ compensation measures for these species in the event the Secretary of State (SoS) disagrees with the assessment. This report should be read alongside the Project’s Ornithology Compensation Strategy (Part 7, Document 7.3).

2.2.2 Reducing the unnecessary bycatch of seabirds increases the survival rate of individuals and can lead to a recovery of populations. Consequently, bycatch mitigation is being proposed by the Applicant as a 'without prejudice' compensation option and is the focus of this report.

2.2.3 Seabirds are one of the most threatened groups of birds (Dias *et al*. 2019; BirdLife International, 2018), encountering a range of factors driving variation in survival and breeding success, such as prey availability, seabird bycatch, and predation. A recent review highlighted seabird bycatch as having the greatest average impact on seabirds across the world (Dias *et al*. 2019). Seabird bycatch can drive reduction in survival of seabird populations, and drive consequent population declines. Gannet, guillemot and razorbill are three seabird species that are vulnerable to this pressure in the UK (Northridge *et al*. 2020).

2.2.4 This report firstly provides an overview of the ecological evidence that gannet, guillemot and razorbill can benefit from bycatch mitigation, followed by a roadmap for the delivery, including information on potential implementation, monitoring and biosecurity that may be required to ensure the measure is successful. Potential fisheries and their suitability for bycatch mitigation measures are identified throughout.

3 Methodology

3.1 Literature review

3.1.1 A literature review was undertaken to determine the key fishing gears causing gannet, guillemot and razorbill bycatch in the UK. This process also aimed to estimate bycatch numbers, and explore potential bycatch reduction techniques. Literature searches included, but were not limited to, scientific journals, government reports, relevant websites (e.g. RSPB), and grey literature. A large body of evidence has already been compiled by previous projects (Ørsted, 2021; Ørsted, 2022) and therefore where possible these reports have been referenced rather than providing duplicated material.

3.2 Data review

3.2.1 A database search was undertaken to identify relevant bycatch data, utilising sites such as the JNCC, MMO, ICES and Cefas, however no bycatch database was identified. Consequently, data was based of scientific literature, utilising papers on bycatch numbers and population impacts by Northridge *et al*. (2020) and Miles *et al*. (2020).

4 Knowledge of bycatch issue

4.1 Introduction

4.1.1 Bycatch refers to the incidental capture of non-target species by fisheries. This process can have significant impacts on seabird populations, representing one of the top threats to seabirds globally (Dias *et al*. 2019; Croxhall *et al*. 2012). This impact is predominantly driven by large-scale fisheries, especially longline and trawl fisheries (Dias *et al*. 2019).

4.1.2 A review of seabird sensitivities to bycatch identified gannet, guillemot and razorbill as some of the most sensitive species to bycatch, with gannet being the most vulnerable species to surface gears, and guillemot and razorbill being the first and second most sensitive to pelagic gears respectively (Bradbury *et al*. 2017).

4.2 Gannet

Introduction

4.2.1 The Northern gannet is the largest of the *Sulidae* family with a wingspan measuring greater than 1.5m. The UK currently holds an estimated 220,000 breeding gannet pairs, representing ~60-70% of the global population (RSPB, 2021, Wildlife Trust, 2021). The global northern gannet population is currently increasing, and in the UK, populations are increasing by ~2% per annum (BirdLife International, 2018; JNCC, 2021a).

4.2.2 Gannet generally breed on coastal cliffs around the north of the UK. Currently 21 UK colonies are known, predominantly on offshore islands and stacks (JNCC, 2021a; RSPB 2021).

4.2.3 Gannet predominantly feed on small fish, plunge diving from heights of 30m and diving to depths of up to 20m, though sometimes feeding from the surface (JNCC, 2021a; Wildlife Trust, 2021; Garthe *et al*. 2007). Gannet also feed on fishing vessel discards (JNCC, 2021a). During breeding seasons gannet may forage up to 709km, though the mean range is 120.4km (mean maximum of 315.2km) (Woodward *et al*. 2019).

Evidence of bycatch

4.2.4 Gannet bycatch data is well documented across UK fisheries. The vulnerability of northern gannets was assessed through a risk assessment model by Bradbury *et al*. (2017) which placed gannet in the top ten (of 53) species for surface, pelagic and benthic fishing gear in terms of species sensitivity index score. For surface gear, gannet was the top ranked species, suggesting they are disproportionally affected by surface gears. Among UK fisheries, a median of 318 northern gannets are estimated to be bycaught each year, accounting for 0.7% of annual gannet mortality (Miles *et al.* 2020). A large proportion of this is apportioned to the Celtic Sea region, where an estimated 73.9% of annual gannet bycatch is observed (Miles *et al*. 2020). Among fisheries, longline fishing has been identified as the greatest threat to gannet, with 220 recorded as bycaught in the UK in 2016 and 241 in 2017 (Northridge *et al*. 2020). Secondary to this, high numbers were also observed in static gillnets, with 117 recorded bycaught in 2016 and 102 in 2017. Notably this estimate drops to 58 and 50 respectively when gannet bycatch was extrapolated separately for vessels sizes <10m and >10m as opposed to together.

4.2.5 Gannet bycatch is also well documented across Portuguese fisheries, with Araújo *et al*. (2022) finding longline and fixed gear fisheries presented the highest bycatch risk in Portuguese fisheries for northern gannet. Similarly, findings from Oliveira *et al*. (2021) show northern gannet was the main bycaught species among Portuguese fisheries, accounting for ~76% of bycaught species; an estimated 14,764 individuals are bycaught annually in demersal longlines (<12m) alone, an order of magnitude more than the total predicted mortality across all OWFs in the UK. These fisheries overlap with the main wintering area of UK gannets, and so a large proportion of these mortalities will be individuals from UK SPA populations. Similarly, the Gran Sol fishery located in the west of the UK in the Atlantic Ocean and operated by Spanish fleets is an area of extremely high bycatch rates, with 48 to 141 birds caught per fishing trip. Gannet were among the highest recorded bycatch of seabird species (Anderson *et al*. 2011).

4.2.6 Similar high bycatch levels in longlines are reported from fisheries in the Atlantic Iberian coastal waters (Calado *et al*. 2020). Gannet bycatch was recorded year-round, with bycatch in the summer being largely immature gannets, likely owing to immature birds remaining in southern European waters while adults return to breeding colonies. Within the report, authors conclude that the scale of bycatch recorded could have significant impacts on the whole gannet population, providing considerable scope for bycatch reduction at a strategic scale.

4.2.7 High levels of gannet bycatch, alongside international harvest of gannets, are also recorded in West African waters, reported by Gremillet *et al*. (2020). Though the scale of the issue is unclear, it is highly likely that gannets from the FFC SPA migrate to waters off the coast of north-west Africa in Winter, and consequently are bycaught in these fisheries (Furness *et al*. 2018a; McGregor *et al*. 2022).

4.3 Guillemot and Razorbill

Introduction

4.3.1 Common guillemot are widely distributed across the UK and Irish coasts, predominantly breeding on low-lying flat-topped islands and stacks, and on broad and narrow cliff ledges (Tuck, 1960; Parslow, 1966). The UK guillemot has fluctuated over the last 50 years, though positive trends have been evident since 2015 with the population reaching its highest value to date in 2019 (JNCC, 2021b).

4.3.2 During feeding, guillemots dive from the sea surface to feed on small fish, using their wings to propel themselves to depths of at least 100m. In the North Sea, the diets of guillemots comprise of ~70% fish, with summer diets predominantly being sandeel and sprat, with a more varied diet over winter (Anderson *et al*. 2013).

4.3.3 Razorbill show a similar distribution to guillemot, predominantly nesting on small ledges or in cracks of rocky cliffs and in associated scree and boulder fields around the UK coastline (JNCC, 2020). UK Razorbill populations have been undergoing an increase since 2013, though numbers have undergone a steep decline from 2017 onwards (JNCC, 2021c).

4.3.4 Similar to guillemot, razorbill use their wings to propel themselves underwater, though dive to shallower depths. The North Sea populations predominantly feed on sandeel, with sprat and herring also part of their diet (ICES, 2011).

Evidence of bycatch

4.3.5 Both guillemot and razorbill bycatch is well documented in UK fisheries. The vulnerability of both species to bycatch was assessed by Bradbury *et al*. (2017), finding both species to be in the top ten vulnerable species across surface, pelagic and benthic fishing gears. Additionally, guillemot and razorbill were the first and second most vulnerable species to pelagic gears respectively. Consequently, trawl and set net (gillnet) fisheries are considered within this document, owing to the greater risk of bycatch of auk species within these gears.

4.3.6 Based on work undertaken by Northridge *et al*. (2020), 27 guillemots and 3 razorbills were recorded bycaught across 2,239 midwater trawls sampled between 1996-2018, while 267 guillemots and 12 razorbills were recorded across 18,916 gillnets over the same time period. Data for this study was predominantly focussed on UK waters, and the sampling indicated that the majority of guillemot and razorbill bycatch occurred in southwest England and the English Channel. In addition, a bycatch hotspot was identified off east England near the FFC SPA but this fishery has since been shut down.

4.3.7 Analysis undertaken by Miles *et al*. (2020), based on data from Northridge *et al*. (2020), estimated a median of 1,985 guillemots and 130 razorbills are bycaught in UK set net fisheries in the UK European Economic Zone (EEZ), representing 1.7% and 0.4% of annual guillemot and razorbill mortality respectively. Notably, analysis by Northridge *et al*. (2020) did not include sampling from non-UK vessels fishing in UK waters, meaning the presented results likely underestimate total bycatch levels. The potential population increases that could be achieved by implementing bycatch mitigation as a compensation option may therefore be higher than expected based on expectations from Northridge *et al*. (2020).

4.3.8 Notably current UK bycatch is likely to be reduced relative to these presented values, with measures put into place following the sampling period (1996-2018) including:

- Bycatch mitigation in Filey bay, reducing guillemot and razorbill bycatch in gillnet fisheries from ~200 guillemots and ~323 razorbills in 2008 to an average of 11 guillemots and 43 razorbills per year between 2010-2014 (Quayle, 2015); and
- A reduction in set net fishing effort owing to declines in salmon stocks to critically low levels.

4.3.9 However, despite these measures, it is noted that bycatch imposed at Filey bay included limiting gillnet fishing to 0500 to 2100 in June (Quayle, 2015) may not be hugely effective, since peak foraging activity of guillemot and razorbill occurs around sunrise and sunset, with both species rarely foraging at night (Cleasby *et al*. 2020). Recorded reductions are instead likely attributable to high attendance of fishers at nets with the aim of releasing entangled birds, alongside the use of high visibility corline. Additionally, while salmon net use has reduced, set nets are still widely used for sea trout, with these likely to be a major contributor to guillemot and razorbill bycatch (Environment Agency, 2020).

4.3.10 Bycatch of guillemot is also documented across foreign fleets. A study of bycatch in the Baltic Sea gillnet fishery estimated that 8,078 guillemots are trapped in salmon gillnets each year, with 3,029 birds killed on average each year with many of these likely having connectivity to British populations (Österblom *et al*. 2002).

5 Bycatch reduction technologies

5.1 Introduction

5.1.1 To mitigate the impacts of bycatch on seabird populations, a range of bycatch reduction measures are available. This section provides an overview of current available measures.

5.1.2 Based on guidance by O'Keefe *et al*. (2012), a bycatch reduction technique should fill at minimum the following criteria in order to be successful:

- Reduce identified bycatch or discards;
- Does not negatively affect target catch rate;
- Does not increase the bycatch of other vulnerable species;
- Does not lead to spatial or temporal displacement of bycatch;
- Does not negatively impact the ecosystem; and
- Is economically viable for a fishery.

5.1.3 Given the increased susceptibility of gannet to bycatch in longlines, mitigation measures specific to longlines will be considered for this species. Similarly, bycatch reduction methods specific to static nets, predominantly gillnets, will be considered for guillemot and razorbill.

5.2 Reduction of gannet bycatch in longline fisheries

5.2.1 Methods to reduce longline bycatch generally fall into five categories which aim to mitigate against incidental seabird mortality (Parker, 2017):

- Reduction in the window of time seabirds can access baited hooks;
- Scare birds away from risk areas when lines are set or hauled;
- Reduce attraction for seabirds to the risk area;
- Make baits 'cryptic' so seabirds cannot see the bait (and therefore not take it); and
- Apply spatial or temporal restrictions to fishing areas

5.2.2 Trials on similar species alongside information on gannet behaviour can be used as an indication of potential success of bycatch reduction technologies. For example, gannets are plunge diving species, and trials on other plunge diving species such as terns, boobies and petrels (American Bird Conservancy, 2016) may be used as a surrogate species to indicate potential success. Similarly, gannets are known to dive up to a depth of 20m, and so knowing whether a technique excludes bycatch up to this depth can be used as an indication for potential success for gannet bycatch reduction in the absence of species-specific trials.

Longlist of bycatch reduction measures for gannet in longline fisheries

5.2.3 A longlist of potential bycatch reduction measures in relation to criteria set by Parker (2017) is presented in Table 5.1.

Table 5.1: Longlist of potential longline bycatch reduction measures for gannet based on criteria by Parker (2017)

Thematic Measure (based on Parker, 2017)	Potential Bycatch Reduction Techniques
Reduce time birds can access baited hooks	Weighted lines
	Sliding leads
	Side setting
	Hooking position
	Bait thaw status
	Branchline hauler
Scare birds away from risk areas	Bird scaring lines
	Scary bird
	Water cannons
Reduce attraction to seabirds	Discard ban
	Fish oil deterrents
Make baits 'cryptic'	Hook shielding
	Dyed bait
	Underwater bait setter
Spatial or temporal restrictions	Night setting
	Fisheries closures and restrictions

5.2.4 The potential effectiveness of longlist measures was assessed through an evaluation, based on an assessment undertaken for Hornsea Project Four (Ørsted, 2021), and is presented in Table A 1 in the Appendix. Changes made to the longlist since its presentation for Hornsea Four include:

- The addition of spatial or temporal restrictions (e.g. Night setting); and
- Altering the table structure to group measures according to thematic measures based on Parker (2017).

Shortlist of bycatch reduction measures for gannet in longline fisheries

5.2.5 Based on the evaluation set out in Table A 1, a shortlist of potential methods has been produced. Selection for the shortlist was based on the measure having no recorded negative impacts on fisheries, while being effective at reducing bycatch. Shortlisted methods were:

- Lumo Leads (weighted line);
- Side setting with bird scaring lines;
- Night setting;
- Scary bird; and
- Hook shielding.

Lumo Leads (weighted line), side setting/night setting and bird-scaring lines

5.2.6 Weighted lines, side setting/night setting and bird-scaring lines are considered together in this section, owing to evidence presented by Melvin *et al*. (2014), and the Agreement on the Conservation of Albatrosses and Petrels (ACAP) (ACAP, 2019), that a combination of these measures is considered best practice and consequently the most effective. These measures are also evidenced as highly effective and suggested as mitigation measures within the EU Seabird Bycatch Action Plan[1].

5.2.7 Lumo leads, developed by FishTek Marine, work by adding weight to baited hooks, reducing the time available for gannets (and other birds) to access baited hooks (Parker, 2017). They offer benefits over general line weighting since they reduce the occurrence of flybacks (when a weight flies back toward the vessel because of line breakages, endangering crew members).

5.2.8 Trials show that Lumo leads both increase the sink rate as well as reduce seabird bycatch (Pierre *et al*. 2015; Claudino dos Santos *et al*. 2016). While trials focused on albatross, petrels and shearwaters as opposed to gannet, the method is expected to be beneficial since it will move the baited hook beyond the maximum foraging depth for gannet (20m) faster, reducing the opportunity for gannet to come into contact with the hook.

5.2.9 Side-setting involves deploying baited hooks from the side of the vessel instead of the stern, aiming to reduce seabird interactions with baited hooks since seabirds generally forage behind vessels. Consequently, by the time hooks reach the stern of the vessel due to drag, they will be below the reach of diving seabirds, reducing potential bycatch (Parker, 2017; CleanCatch UK, 2021). Similarly, night setting involves setting nets at night only, with the aim of avoiding times when birds are more likely to be foraging.

5.2.10 Bird scaring lines act as a protective curtain, deterring birds from entering the area where baited hooks are sinking (Parker, 2017). Since birds are visual foragers, the brightly coloured streamers of bird scaring lines distract birds and reduce their interaction with hooks.

5.2.11 As a standalone measure, night-setting has shown to have a consistently positive effect in reducing bycatch in a range of species and regions (Jimenez *et* al. 2020; Murray *et al*. 1993; Brothers *et al*. 1999; Jimenez *et al*. 2009, Jimenez *et al*. 2014; Petersen *et al*. 2009). The effectiveness is variable among species, with the measure being less effective for species showing higher nocturnal activity (e.g. fulmar; Anderson *et al*. 2022). However, considering the minimal levels of flight and diving activity shown by gannet during night and twilight hours (Furness *et al*. 2018b), night setting is considered likely to be an effective bycatch mitigation, and consequently compensation method for this species.

5.2.12 The effectiveness of bird-scaring lines is also well evidenced. Across fishing trials in the North Atlantic, the use of bird-scaring lines 'virtually eliminated' seabird bycatch, reducing it by 98-100% (Lokkeborg, 2003), while work in Portugal found bird-scaring lines reduce the presence of gulls at fishing vessels by 11% (Oliveira *et al*. 2020). It was also noted in this study that target catch rates were increased, likely as a result of reduced bait loss from seabirds.

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[1] https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:52012DC0665

5.2.13 While evidenced as effective measures alone, these 3 measures are considered more effective when used in combination. The use of weighted lines combined with two bird-scaring lines showed to reduce bird attacks by a factor of four and seabird mortality by a factor of seven compared with unweighted lines, and the addition of night setting resulted in zero bird mortalities (Melvin *et al*. 2014). Similarly, the use of bird-scaring lines in combination with line weights showed to reduce seabird bycatch (including Cape gannets) by 100% in Namibia (Paterson *et al*. 2019).

5.2.14 Based on the evidence presented above, all three measures are considered be effective options for gannet when used alone, though based on available evidence the combination of either two or all three of the measures is considered the most effective option. Notably the above evidence is predominantly based on albatrosses and petrels and across southern African fisheries with less work on gannet specifically, though considering their similar ecology it is considered highly likely the measures will be as effective for gannet. And so further research may be needed to better evidence the expected benefits of these measures for gannet in UK waters.

Hook shielding

5.2.15 Hook shielding works by guarding the barb of the hook, making it inaccessible to seabirds so they cannot be bycaught. The shield automatically retracts at a set depth which is below the diving depth of the seabird (20m for gannet). Currently two highly developed technologies using hook shielding are available: (1) Smart Tuna Hook, and (2) Hookpod.

5.2.16 The Hookpod is recommended by the ACAP Seabird Bycatch Working Group (SBWG) as a stand-alone best practice measure in surface longlines, indicating it has achieved the six ACAP Seabird Bycatch Mitigation Criteria (Parker, 2017). Evidence across 18 trials in South African, Brazilian and Australasian waters have shown that the measure can reduce bycatch from 0.8 birds/1000 hooks to 0.04 birds/1000 hooks with no impact on catch rate of target species (Sullivan *et al*. 2017).

5.2.17 Trials have focused on albatross and petrels as opposed to gannet, though there is high potential for this measure to be beneficial to gannet, since the depth at which hooks are made accessible can be set to 20m, beyond the range of diving gannets.

SCARYBIRD

5.2.18 SCARYBIRD is a potential bycatch measure comprised of a predator silhouette with a harrier shape, presented by Oliveira *et al*. (2020). Though data on the measure is limited at this stage, it was noted that SCARYBIRD represents a low-cost (<5% income of a single day's landings), and that is has the potential to reduce bycatch, with a reduction in interaction of birds (especially gulls) with the fishing vessel recorded.

5.3 Reduction of guillemot and razorbill bycatch in gillnet fisheries

5.3.1 Despite widespread evidence of bycatch of seabirds in gillnet fisheries, there is a lack of widespread implementation of bycatch reduction techniques. Methods are predominantly based around increasing the visibility of fishing gear to seabirds

5.3.2 Based on an evidence review undertaken for Hornsea Four, a longlist of gillnet bycatch reduction methods was created and is presented in Table 5.2. Changes made to the longlist since it's presentation for Hornsea Four include:

- The addition of 'training fishers to safely remove tangled birds';
- The alteration of 'raptor silhouettes' to 'predator silhouettes' and addition of relevant research for the measure (notably Oliveira *et al*. 2020); and
- The addition of a lack of confidence in 'Acoustic deterrents', owing to a lack of reliable data since the publication of Melvin *et al*. (1999), work by Martin and Crawford (2015) indicating a lack of confidence in the measure due to the inability of auks to accurately locate sounds underwater, and work by Manly (2007) indicating acoustic deterrents can result in higher levels of seabird bycatch.

5.3.3 Worldwide, efforts to reduce bycatch in gillnet fisheries are limited in comparison to longline fisheries, with current successful research largely focused on increasing net visibility (Parker *et al*., 2019). Consequently, measures are not presented according to thematic measures as in Section 5.2, with measures instead grouped into appropriate themes presented in Table 5.2.

Table 5.2: Longlist of potential gillnet bycatch reduction measures for guillemot and razorbill

Thematic Measure	Potential Bycatch Reduction Techniques
Net illumination	Light sticks on nets
	Lights of different colours (LEDs or UV)
Visual net modifications	Reflective nets/ materials in panels
	Mesh sizing
	Contrasting net panels/ rope in mesh
	Coloured/ high visibility nets/ materials
	Silhouettes or predator mimics placed in nets
	Moving/twisting elements or streamers
Above water methods	Net surface markers
	Kites or drones flown over net
	Raptor silhouettes
	Looming eye buoys
Acoustic methods	Multi-frequency pingers
	Audio recordings of predators
Net type and setting	Low profile nets
	Tie downs to reduce profile of net

Thematic Measure	Potential Bycatch Reduction Techniques
	Set depth
	Net height
	Headline drops
	Altered float lines
	Hanging Ratio
	Net weights
Net operations	Adjust setting and hauling times
	Soak times
	Nocturnal setting
	Net sensors (alarm, light)
	Net-checking frequency
	Training fishers to safely release birds
Operational fishing measures	Fisheries closures (area/seasonal)
	Gear-switching/restrictions

5.3.4 The potential effectiveness of longlist measures was assessed through an evaluation, based on an assessment undertaken for Hornsea Project Four (Ørsted 2021), and is presented in Table A 2.

Shortlist of bycatch reduction measures for guillemot in gillnet fisheries

5.3.5 Based on the evaluation set out in Table A 2, a shortlist of potential methods has been produced, with shortlisted measures prioritised based on the measure being effective at reducing bycatch, while having no negative impacts on fisheries. Shortlisted measures which are given further consideration below include:

- Net illumination;
- Visual net modifications (reflective nets and high visibility nets); and
- Above water deterrents.

Net illumination and visual net modifications

5.3.6 Both net illumination and visual net modifications aim to make nets more visible to seabirds, informing them of the location of nets and reducing the incidence of bycatch and so are considered together in this section.

5.3.7 Since seabirds are generally visually guided foragers, they are likely to be highly receptive to visual alerts such as lights and highly visible netting while underwater (Martin and Crawford, 2015). Work by Wang *et al*. (2013), has shown that the use of lighting on nets can not only reduce sea turtle bycatch, but that lights can also attract fish species, therefore having no adverse impacts on turtle species or the fisher’s catch.

5.3.8 Net illumination has also shown to be effective among seabird species, with Mangel *et al*. (2018) and Bieli *et al*. (2020) reporting ~80% declines in cormorant, petrel, penguin and shearwater bycatch in gillnets in Peru following the use of LEDs. Chemical light sticks have also shown to be effective in reducing seabird bycatch in gillnets (Wiedenfeld *et al*. 2015), though it is noted that light sticks would need to be changed regularly (every ~12 hours) and so would not be suitable for fisheries with longer soak times, and the measure also poses a plastic waste issue owing to the non-reusable nature of light sticks.

5.3.9 Similar results may also be achieved with the use of more visible netting in gillnets. Quayle (2015) report a reduction in guillemot and razorbill bycatch in Filey Bay following the use of high visibility corline in the leader/tailpiece of the net. Notably, this measure was combined with other measures (LEBs and training of fishers to safely remove seabirds from nets) and so the reduction in bycatch cannot solely be attributed to this measure.

5.3.10 An additional measure available is the use of warning panels, as opposed to lights. Martin and Crawford (2015) note that the effectiveness of lights may be limited by the effects of the adaptation of seabird retina to ambient light levels while diving; the exposure to a light source at low ambient light levels will result in visual impairment for a short time period, reducing the ability of birds to see non-illuminated sections of the net until the eye has adapted to ambient light. To alert diving birds to gillnets without disrupting the dark-adapted state of the animal's retinas, Martin and Crawford (2015) propose the use of 60 cm x 60 cm warning panels, decorated in a black and white checkerboard or grating pattern. Their proposed design is expected to be visible to species such as cormorants from up to 20m away under clear conditions. Current trials show mixed results, with Field *et al*. (2019) reporting an increase in seabird bycatch, and Almieda *et* al. (2017) reporting a reduced, but non-significant, reduction in bycaught seabirds.

Above water deterrents

5.3.11 Deterrents above water can be used to reduce the number of individuals foraging in the area around the net. This may drastically reduce bycatch even in turbid conditions, since seabird eyesight is clearer above water.

5.3.12 A range of above water deterrents are available for use, including (but not limited to): net surface markers, kites, predator silhouettes, and looming eye buoys (LEBs). Implementation of above water deterrents has the potential to offer greater benefits compared with underwater deterrents, owing to the ability to continue using the measure effectively during periods (or areas) or low underwater visibility.

5.3.13 Looming eye buoys (LEBs) consists of a three-dimensional rotating panel that simulates large eye patterns. They are one measure that have already been utilised by Hornsea Four, and provide a simple, low-cost solution to adapt the buoys that support the hanging net. The measure aims to reduce seabird presence from a 50m radius, which is longer than the horizontal diving distance of guillemot and razorbill (Rory Crawford, RSPB pers. Comm.). This measure has previously shown to deter some species (e.g. long-tailed ducks) from approaching the net, with Rouxel *et al*. 2021 reporting a 30% reduction in long-tailed duck presence within 50m of the buoys. More recently, results presented by Ørsted (2022) over the 2021/22 nonbreeding season show that LEB's may reduce auk bycatch in active fisheries, with a 25% reduction in guillemot bycatch shown. Based on the above evidence, LEBs are considered a feasible compensation measure for Outer Dowsing, though consideration will continue to be given to results originating from both RSPB and Hornsea Four's current LEB trials.

5.3.14 With trials undertaken in Portuguese waters, an additional promising measure is the use of 'SCARYBIRD', a predator silhouette with a harrier shape (Oliveira *et al*., 2020). Though data on the measure is limited at this stage, it was noted that SCARYBIRD represents a low-cost (<5% income of a single day's landings), that has the potential to reduce bycatch by reducing interactions between birds (especially gulls) and the fishing vessel.

6 Roadmap for delivery

6.1 Design and implementation

6.1.1 As per Section 5.2, the shortlisted measures (weighted lines, bird-scaring lines, side setting/night setting, hookpods and SCARYBIRD) will be considered further as potential compensation options for gannet. Based on the evidence presented throughout Section 5.2, these shortlisted measures are deemed likely to have a high chance of success in terms of delivering measurable benefits to gannets, while having minimal negative impacts on fisheries. For guillemot and razorbill, net illumination, visual net modifications, and above water deterrents will be further considered.

6.1.2 Before implementation, a risk-mapping exercise will also be undertaken to highlight high-risk fisheries and determine locations and fisheries where bycatch levels are highest and mitigation can be successfully implemented.

6.1.3 Following identification of key fisheries and/or locations, a feasibility study will be undertaken on shortlisted measures. The feasibility study will incorporate either one or multiple of the measures outlined in Section 5.2, with the goal of filling identified knowledge gaps, with the most notable evidence need being a greater understanding of the expected quantifiable benefit of the bycatch reduction measure(s) to gannets in UK waters. Detailed delivery proposals outlining this process will be presented in the Gannet, Guillemot and Razorbill CIMP.

6.1.4 It is noted that bycatch trials for LEBs for guillemot and razorbill are currently being undertaken by Hornsea Project Four, and the outcome of the examination process will inform the next steps.

6.2 Timescales

6.2.1 Based on available evidence of the shortlisted measures (e.g. Quayle, 2015), it is expected that the benefits of implemented measures will be effective immediately. Since measures are expected to reduce bycatch of adult gannets, guillemots and razorbills (alongside any other age classes present), the implemented measures will compensate one to one for losses to impacts from Outer Dowsing, with no delay. Measures will therefore be introduced as soon as required for compensation and, where possible, in advance of the need for compensation. Considering that bycatch mitigation can start to provide compensation immediately at a one-to-one ratio it is a valuable option to be used within a suite of measures to reduce the build-up of a mortality debt and provide effective compensation earlier in the project's lifetime.

6.3 Consultation

6.3.1 Engagement with stakeholders will be required through all stages of the development of the bycatch reduction measure(s).

6.3.2 To assist in the delivery of site selection, implementation, reporting and other relevant matters as determined by the Applicant, a steering group named the Offshore Ornithology Engagement Group (OOEG) will be convened following consent award for Outer Dowsing OWF. Core members of the OOEG will be specified by the Secretary of State (SoS) but is likely to include the Marine Management Organisation (MMO), relevant Inshore Fisheries & Conservation Authorities (IFCA), The National Federation of Fishermen's Organisations (NFFO) and/or other relevant fishing industry representation and relevant Statutory Nature Conservation Bodies (SNCBs).

6.3.3 During implementation of the compensation measure, consultation with stakeholders via the OOEG process will be undertaken to ensure cooperation across the monitoring aspects of the compensation measure. To ensure the implemented bycatch reduction measure(s) are being applied in accordance with the CIMP, details of the monitoring phase will be discussed with the OOEG and set out within the CIMP for approval by secretary of state.

6.3.4 Monitoring will also inform any adaptive management measures required to ensure that the compensation is successful. Any potential adaptive management measures will be discussed with the OOEG members before implementation.

6.4 Monitoring and adaptive management

6.4.1 A detailed monitoring and adaptive management plan will be provided in the CIMP. This will be produced in consultation with OOEG members and other relevant parties.

Monitoring

6.4.2 A monitoring package will be designed with the delivery partner and the OOEG. Monitoring will aim to quantify the reduction in bycatch numbers for guillemot, razorbill and gannet. This would be achieved by comparing bycatch rates across a series of control nets and those using bycatch mitigation technology. The monitoring of results will be dependent on the implementation method. However, this is a well-known methodology to quantify bycatch reduction. This would be developed with experienced stakeholders from both a conservation and fisheries background to ensure monitoring requirements are met. The method and frequency of monitoring the compensation measure will be detailed in the CIMP.

Adaptive management

6.4.3 If the bycatch reduction measure appears less successful than planned, then adaptive management measures will be explored, aiming to improve the effectiveness of the measure while also updating knowledge and improving future decisions. The CIMP will outline an adaptive management plan, listing a set of potential options to ensure the long - term resilience of the measure. This process will be developed in consultation with the OOEG.

6.4.4 In the event of the bycatch reduction measure being unsuccessful, adaptive management will aim to either improve the effectiveness of the measure, implement another technique, and/or implement in another fishery/fishery type. All adaptive management options will be developed with the OOEG and the agreed option implemented following this consultation process.

6.4.5 An alternative approach may be for the Applicant to contribute to a fund as an adaptive management measures, such as the Marine Recovery Fund (MRF).

6.5 Strategic approach

6.5.1 As highlighted in Section 6.1, options for the implementation of bycatch mitigation may be limited and consideration to the outcome of the Hornsea Four examination will need to be taken into account. Consequently, consideration will be given to the potential for a collaborative delivery model, delivering bycatch mitigation with one or more other OWF developers.

6.6 Legal agreement(s)

6.6.1 Legal agreements to facilitate bycatch reduction measures will be undertaken as necessary.

6.7 Key consents

6.7.1 Alongside securing relevant land rights, the Applicant will assess the need for any site-specific consents.

6.7.2 Further details on proposed locations and associated agreements will be presented as part of the DCO Application.

6.8 Funding

6.8.1 A funding statement will be submitted as part of the DCO Application, which will include consideration of the costs associated with any bycatch reduction measure(s).

7 References

Almeida, A., Ameryk, A., Campos, B., Crawford, R., Krogulec, J., Linkowski, T., Mitchell, R., Mitchell, W., Oliveira, N., Oppel, S. and Tarzia, M. (2017), 'Study on mitigation measures to minimise seabird bycatch in gillnet fisheries'.

American Bird Conservancy. (2016), 'Seabird bycatch solutions for fishery sustainability', The Walton Family Foundation.

Anderson, O., Small, C., Croxall, J., Dunn, E., Sullivan, B., Yates, O. and Black, A. (2011), 'Global seabird bycatch in longline fisheries', Endangered Species Research 14/2: 91-106.

Anderson, H. B., Evans, P. G., Potts, J. M., Harris, M. P. and Wanless, S. (2013), 'The diet of Common Guillemot Uria aalge chicks provides evidence of changing prey communities in the North Sea', Ibis 156/1: 23-34.

Anderson, O. R. J., Thompson, D. and Parsons, M. (2022), 'Seabird bycatch mitigation: evidence base for possible UK application and research', JNCC Report No. 717, JNCC, Peterborough. ISSN 0963-8091. https://hub.jncc.gov.uk/assets/dbed3ea2-1c2a-40cf-b0f8-437372f1a036.

Araújo, H., Correia-Rodrigues, P., Debru, P., Ferreira, M., Vingada, J. and Eira, C. (2022), 'Balearic shearwater and northern gannet bycatch risk assessment in Portuguese Continental Waters'. Biological Conservation, 267: 109463.

Bielli, A., Alfaro-Shigueto, J., Doherty, P. D., Godley, B. J., Ortiz, C., Pasara, A., Wang, J. H. and Mangel, J. C. (2020), 'An illuminating idea to reduce bycatch in the Peruvian small-scale gillnet fishery', Biological Conservation, 241: 108277.

BirdLife International. (2018), 'Morus bassanus. The IUCN Red List of Threatened Species 2018: e.T22696657A132587285'. https://dx.doi.org/10.2305/IUCN.UK.2018-2.RLTS.T22696657A132587285.en [Accessed July 2022].

Bradbury, G., Shackshaft, M., Scott-Hayward, L., Rexstad, E., Miller, D. and Edwards, D. (2017), 'Risk assessment of seabird bycatch in UK waters', Report prepared for the Department for Environment Food and Rural Affairs (Project Code MB0126).

Brothers, N., Gales, R. and Reid T. (1999), 'The influence of environmental variables and mitigation measures on seabird catch rates in the Japanese tuna longline fishery within the Australian Fishing Zone, 1991-1995' Biological Conservation, 88: 85-101.

Calado, J. G., Ramos, J. A., Almeida, A., Oliveira, N. and Paiva, V. H. (2020), 'Seabird-fishery interactions and bycatch at multiple gears in the Atlantic Iberian coast', Ocean and Coastal Management, 200: 105306.

Claudino dos Santos, R., Silva-Costa, A., Sant'Ana, R., Gianuca, D., Yates, O., Marques, O. and Neves, T. (2016), 'Comparative trails of Lumo Leads and traditional line weighting in the Brazilian pelagic long-line fishery', Seventh Meeting of the Seabird Bycatch Working Group, ACAP, La Serena, Chile.

Clean Catch UK, (2021), 'The Bycatch Mitigation Hub - Clean Catch UK'. https://www.cleancatchuk.com/hub/ [Accessed September 2022].

Cleasby, I. R., Owen, E., Wilson, L., Wakefield, E. D., O'Connell, P. and Bolton, M. (2020), 'Identifying important at-sea areas for seabirds using species distribution models and hotspot mapping', Biological Conservation, 241: 108375.

Croxall, J. P., Butchart, S. H. M., Lascelles, B., Stattersfield, A. J., Sullivan, B., Symes, A. and Taylor, P. (2012), 'Seabird conservation status, threats and priority actions: a global assessment', Bird Conservation International 22: 1-34.

Dias, M., Martin, R., Pearmain, E., Burfield, I., Small, C., Phillips, R., Yates, O., Lascelles, B., Borboroglu, P. and Croxall, J. (2019), 'Threats to seabirds: A global assessment', Biological Conservation, 237: 525-537.

Environment Agency, (2020), 'Consultation Report: Options for extending the sea trout beach net fishery in Yorkshire and North East England. Environment Agency', Bristol.

Field, R., Crawford, R., Enever, R., Linkowski, T., Martin, G., Morkunas, J., Morkune, R., Rouxel, Y. and Oppel, S. (2019), 'High contrast panels and lights do not reduce bird bycatch in Baltic Sea gillnet fisheries', Global Ecology and Conservation, 18: 00602.

Furness, R. W., Hallgrimsson, G. T., Montevecchi, W. A., Fifield, D., Kubetzki, U., Mendel, B. and Garthe, S. (2018a). Adult Gannet migrations frequently loop clockwise around Britain and Ireland. *Ringing & Migration*, 33/1: 45-53.

Furness, R. W., Garthe, S., Trinder, M., Matthiopoulos, J., Wanless, S. and Jeglinski, J. (2018b), 'Nocturnal flight activity of northern gannets Morus bassanus and implications for modelling collision risk at offshore wind farms', Environmental Impact Assessment Review, 73: 1-6.

Garthe, S., Montevecchi, W. and Davoren, G. (2007), 'Flight destinations and foraging behaviour of northern gannets (Sula bassana) preying on a small forage fish in a low-Arctic ecosystem. Deep Sea Research Part II: Topical Studies in Oceanography, 54/3-4: 311-320

Gremillet, D., Peron, C., Lescroel, A., Fort, J., Patrick, S., Besnard, A. and Provost, P. (2020), 'No way home: collapse in northern gannet survival rates point to critical marine ecosystem perturbation', Marine Biology 167: 189.

ICES. (2011), 'Report of the Working Group on Multispecies Assessment Methods (WGSAM)', 10–14 October 2011, Woods Hole, USA. ICES Document CM 2011/SSGSUE: 10.

Jiménez, S., Domingo, A. & Brazeiro A. (2009), 'Seabird bycatch in the Southwest Atlantic: interaction with the Uruguayan pelagic longline fishery', Polar Biology, 32/2: 187-196.

Jiménez, S., Phillips, R. A., Brazeiro, A., Defeo, O. and Domingo A. (2014), 'Bycatch of great albatrosses in pelagic longline fisheries in the Southwest Atlantic: contributing factors and implications for management', Biological Conservation, 171: 9-20.

Jiménez, S., Domingo, A., Winker, H., Parker, D., Gianuca, D., Neves, T., Coelho, R. and Kerwath S. (2020), 'Towards mitigation of seabird bycatch: Large-scale effectiveness of night setting and Tori lines across multiple pelagic longline fleets', Biological Conservation, 247: 108642.

JNCC. (2021a). 'Northern Gannet (Morus bassanus)'. https://jncc.gov.uk/our-work/northern-gannet-morus-bassanus/ [Accessed October 2022].

JNCC. (2021b). 'Guillemot (Uria aalge)'. https://jncc.gov.uk/our-work/guillemot-uria-aalge/ [Accessed October 2022]

JNCC. (2021c). 'Razorbill (Alca torda)'. https://jncc.gov.uk/our-work/razorbill-alca-torda/ [Accessed October 2022].

Lokkeborg, S. (2003), 'Review and evaluation of three mitigation measures – bird-scaring line, underwater setting and line shooter – to reduce seabird bycatch in the north Atlantic longline fishery', Fisheries Research, 60/1: 11:16.

Mangel, J. C., Wang, J., Alfaro-Shigueto, J. Pingo, S., Jimenez, A., Carvalho, F., Swimmer, Y. and Godley, B. (2018), 'Illuminating gillnets to save seabirds and the potential for multi-taxa bycatch mitigation', Royal Society Open Science, 5: 180254.

Manly, B. F. J. (2007), 'Incidental take and interactions of marine mammals and birds in the Kodiak Island salmon set gillnet fishery, 2002 and 2005', Final Report to NMFS Alaska Region, Western EcoSystems Technology, Cheyenne, USA.

Martin, G. R. and Crawford, R. (2015), 'Reducing bycatch in gillnets: A sensory ecology perspective', Global Ecology and Conservation, 3, 28–50.

McGregor, R., Trinder, M. and Goodship, N. (2022), 'Assessment of compensatory measures for impacts of offshore windfarms on seabirds', A report for Natural England. Natural England Commissioned Reports (Report number NECR431).

Melvin, E. F., Parrish, J. K. and Conquest, L. L. (1999), 'Novel tools to reduce seabird bycatch in coastal gillnet fisheries', Conservation Biology, 13, 1386-1397.

Melvin, E. F., Guy, T. J. and Read, L. B. (2014), 'Best practice seabird bycatch mitigation for pelagic longline fisheries targeting tuna and related species', Fisheries Research, 149, 5-18.

Miles, J., Parsons, M. and O'Brien, S. (2020), 'Preliminary assessment of seabird population response to potential bycatch mitigation in the UKregistered fishing fleet', Report prepared for the Department for Environment Food and Rural Affairs (Project Code ME6024).

Murray, T. E., Bartle., J. A. Kalish., S. R. and Taylor P. R. (1993), 'Incidental capture of seabirds by Japanese southern bluefin tuna longline vessels in New Zealand waters, 1988-1992', Bird Conservation International, 3: 181-210.

Northridge, S., Kingston, A., and Coram, A. (2020), 'Preliminary estimates of seabird bycatch by UK vessels in UK and adjacent waters', Report prepared for the Department for Environment Food and Rural Affairs (Project Code ME6024).

O'Keefe, C. E., Cadrin, S. X. and Stokesbury, K. D. (2012), 'Evaluating success of bycatch mitigation measures', ICES CM 2012/C17.

Oliveira, N., Almeida, A., Alonso, H., Constantino, E., Ferreira, A., Gutiérrez, I., Santos, A., Silva, E. and Andrade, J., (2020), 'A contribution to reducing bycatch in a high priority area for seabird conservation in Portugal', Bird Conservation International, 31/4: 553-572.

Ørsted. (2022a), 'Hornsea Project Four Bycatch Reduction Technology Selection Phase Summary'. Deadline: 5, Date: 20 June 2022. Document Reference: G5.13. Revision: 01.

Ørsted. (2021), 'Hornsea Project Four Compensation Measures for FFC SPA: Bycatch Reduction: Ecological Evidence'. Date: September 2021. Document Reference: B2.8.1. Version: A.

Österblom, H., Fransson, T. and Olsson. O. (2002), 'Bycatches of common guillemots (*Uria aalge*) in the Baltic Sea gillnet fishery', Biological Conservation, 105: 309-319.

Parker, G. C. (2017), 'Stocktake of measures for mitigating the incidental capture of seabirds in New Zealand commercial fisheries'. Report to Southern Seabird Solutions Trust by Parker Conservation, Dunedin.

Parslow, J. L. F. (1966), 'Hole-nesting by Guillemots', British Birds, 59: 120-121.

Paterson, J. R., Yates, O., Holtzhausen, H., Reid, T., Shimooshili, K., Yates, S., Sullivan, B. J. and Wanless, R. M. (2019), 'Seabird mortality in the Namibian demersal longline fishery and recommendations for best practice mitigation measures', Oryx, 53: 300-309.

Petersen, S. L., Honig, M. B., Ryan, P. G. and Underhill L. G. (2009), 'Seabird bycatch in the pelagic longline fishery off southern Africa'. African Journal of Marine Science, 31: 191-204.

Pierre, J. P., Goad, D. W., Abraham, E. R. (2015), 'Novel approaches to line-weighting in New Zealand's inshore surface-longline fishery', Final Report prepared for the Department of Conservation: Conservation Services Programme project MIT2012-04.

Quayle, H. (2015), 'Filey Bay: Safe Seas for Seabirds', RSPB report.

RSPB. (2021), 'Gannet Bird Facts | *Morus bassanus*'. https://www.rspb.org.uk/birds-and-wildlife/wildlife-guides/bird-a-z/gannet/ [Accessed July 2022].

Sullivan, B. J., Kibel, B., Kibel, P., Yates, O., Potts, J. M., Ingham, B., Domingo, A., Gianuca, D., Jimenez, S., Lebepe, B., Maree, B. A., Neves, T., Peppes, F., Rasehlomi, T., Silva-Costa, A. and Wanless, R. M. (2017), 'At-sea trialling of the Hookpod: a 'one-stop' mitigation solution for seabird bycatch in pelagic longline fisheries', Animal Conservation, 21, 159-167.

Tuck, L. M. (1960), 'The Murres', (Ottawa).

Wang, J., Barkan, J., Fisler, S., Godinez-Reyes, C., Swimmer, Y., (2013), 'Developing ultraviolet illumination of gillnets as a method to reduce sea turtle bycatch', Biology Letters, 9.

Wiedenfeld, D. A., Crawford, R., and Pott, C. M. (2015), 'Results of a Workshop on Reduction of Bycatch of Seabirds, Sea Turtles, and Sea Mammals in Gillnets, 21-23 January 2015', American Bird Conservancy and BirdLife International.

Wildlife Trust. (2021), ‘Northern gannet’. https://www.wildlifetrusts.org/wildlife-explorer/birds/seabirds/northern-gannet [Accessed July 2022].

Woodward, I., Thaxter, C. B., Owen, E., and Cook, A. S. C. P. (2019)’, ‘Desk-based revision of seabird foraging ranges used for HRA screening’, BTO research report number 724.

Table A 1: Review of the effectiveness of longline bycatch mitigation measures for Gannet, updated and adapted from the assessment undertaken for Hornsea Project Four (Ørsted 2021)

Bycatch reduction program	Study species	Bycatch reduced?	No effect on target catch	Is there no effect on non-target catch?	Was there no impact on fishing effort?
Reduce time birds can access baited hooks					
Weighted lines					
Melvin *et al.*, 2011a	White-chinned petrels, yellow-nosed and black-browed albatrosses, and cape gannet	✓	✓ (Gianuca et al., 2013; Parker, 2017)	✓ (Parker, 2017)	-
Jniménez et al., 2013; Robertson et al., 2013	Multiple (not specified)	✓	✓ (Gianuca et al., 2013; Parker, 2017)	✓ (Parker, 2017)	-
Sliding Leads					
N.A. – studies testing safety but not effectiveness against bycatch	-	-	-	-	-
LumoLeads (FishTek Marine Ltd); Claudino dos Santos et al. 2016	Black browed albatross, white chinned petrels, and great shearwaters	✓	✓ No difference in catch rates of target species among treatments	✓ Studies to date show no increase in bycatch of other species (Parker, 2017)	-
Bait Thaw Status					
Klaer and Polacheck, 1998	Multiple (not specified)	✓	-	-	-

Bycatch reduction program	Study species	Bycatch reduced?	No effect on target catch	Is there no effect on non-target catch?	Was there no impact on fishing effort?
Brothers et al., 1995; Robertson et al., 2010 (testing sink rate but not bycatch)	-	X (Conflicting results on sink rate)	-	-	-
Side-setting					
Gilman et al., 2007; Gilman et al., 2016	Laysan and blackfooted albatross	✓ (combined with bird curtain)	-	-	-
Branchline hauler					
-	-	-	-	-	-
Scare birds away from risk areas					
Bird scaring lines					
Melvin *et al.*, 2014	Albatross and petrels	✓	May increase target catch rates as they reduce seabird attacks on baits (reducing bait loss during setting) (Lokkeborg 2011)	Seabird mortality from entanglement with bird scaring lines has been recorded – rare event (Parker, 2017)	-
Løkkeborg and Robertson, 2002;	Northern fulmars	✓			-
Domigo *et al*. 2011	Multiple (not specified)	✓			-
Water cannons					
Kiyota et al. 2001	Multiple (not specified)	✓ (less effective in strong winds)	-	-	-
Reduce attraction to seabirds					
Discard ban					
Clark *et al*., 2019	Gannet	✓	-	-	-
Fish oil deterrents					
Pierre and Norden, 2006	Flesh-footed shearwaters, Buller's	✓	- (No evidence was found in the small	No evidence was found in the small	-

Bycatch reduction program	Study species	Bycatch reduced?	No effect on target catch	Is there no effect on non-target catch?	Was there no impact on fishing effort?
	shearwaters, and black petrels		number of studies conducted indicating catch rates negatively affected (Parker, 2017)	number of studies indicating an impact on other taxa. However, the use of shark oil could potentially encourage sharks to be targeted purely for oil extraction (Parker, 2017)	
Make baits 'cryptic'					
Hook shielding					
FishTek Marine Ltd); Barrington 2016a; Sullivan et al., 2017	Albatross and petrels	✓	✓ No reduction in catch rates identified (Parker, 2017)	✓ No evidence of effects on non-target species identified (Parker, 2017)	-
Smart Tuna Hook; Baker and Candy, 2014; Barrington et al., 2016b	Multiple (not specified)	✓			-
Dyed bait					
Boggs, 2001	Black-footed and Laysan albatrosses	✓	More research needed (Parker, 2017)	✓ (Parker, 2017)	-
Cocking *et al*. 2008	Multiple (majority wedge-tailed shearwaters (and other procellariform seabirds)	✓ (Squid not fish)			-
Underwater bait setter					

Bycatch reduction program	Study species	Bycatch reduced?	No effect on target catch	Is there no effect on non-target catch?	Was there no impact on fishing effort?
Robertson et al. 2015; Robertson pers. Comm. In Parker, 2017	Albatrosses and petrels	✓	✓ (Parker, 2017)	✓ (Parker, 2017)	-
Spatial or temporal restrictions					
Night setting					
Jimenez *et al*. 2020	Multiple (including gannet spp)	✓	-	-	-

Table A 2: Evaluation of the effectiveness of gillnet bycatch reduction measures for guillemot and razorbill, updated and adapted based from the assessment undertaken for Hornsea Project Four (Ørsted 2021),

Bycatch reduction program	Study species	Bycatch reduced?	No effect on target catch	Is there no effect on non-target catch?	Was there no impact on fishing effort?	Is the measure economically viable for fisheries?
Net illumination						
Light sticks						
Wang et al., 2010	Turtles	✓	✓	-	-	X
LEDs or UV						
Mangel et al., 2018	Cormorants	✓	✓	X	-	✓
Bielli et al., 2020	Petrel, penguin, shearwater	✓	-	-	-	-
Field et al., 2019	Sea ducks (green lights)	X	✓	-	-	-
Field et al., 2019	Sea ducks (white lights)	X	X	-	-	-
Visual net modifications						
Reflective nets						
Trippe *et al*. 2003	Shearwater	✓ (combined with bird curtain)	-	-	-	-
Bordino *et al*., 2013	Franciscana	X	✓	-	-	-
Mesh size						
Bærum *et al*., 2019	Seabirds	X	-	-	-	-
Dagys and Žydelis, 2002	Waterbirds	✓	-	-	-	✓
Contrasting warning panels						
Field *et al*., 2019	Sea ducks	X	✓	-	-	-

Bycatch reduction program	Study species	Bycatch reduced?	No effect on target catch	Is there no effect on non-target catch?	Was there no impact on fishing effort?	Is the measure economically viable for fisheries?
Almeida *et al.*, 2017	Seabirds including auks	-	✓	-	X	X
High visibility netting						
Melvin *et al.*, 1999	Guillemot Rhinoceros auklet	✓	✓	✓	-	-
Quayle, 2015	Razorbill Guillemot	✓	✓	-	-	-
Coloured netting						
Hanamseth *et al.* 2017	Penguin	✓	-	-	-	-
Predator mimics						
Wang *et al.*, 2010	Turtle	✓	X	-	-	-
Moving/twisting elements or streamers						
Currently no studies quantifying this technique						
Above water methods						
Looming eyes buoy						
Rouxel *et al.*, 2021	Long-tailed ducks	✓	-	-	-	-
Acoustic methods						
Pingers						
Melvin *et al.*, 1999	Guillemot Rhinoceros auklet	✓	✓	X	-	-
Manly 2007	Multiple (including auks)	X	-	-	-	-
Audio recordings of predators						
Currently no studies quantifying these techniques						

Bycatch reduction program	Study species	Bycatch reduced?	No effect on target catch	Is there no effect on non-target catch?	Was there no impact on fishing effort?	Is the measure economically viable for fisheries?
Net type and setting						
Low profile						
Price and von Salisbury in Gilman *et al.*, 2010	Turtle	✓	X	-	-	-
Armstrong *et al.*, 2013; Wark *et al.*, 2013	Turtle, dolphin	X	X	-	-	-
Set depths						
Hayase and Yatsu, 1993	Shearwater	✓	X	X	-	-
Mangel *et al.*, 2014	Small cetaceans and sea turtles	-	X	-	-	-
Carretta and Chivers, 2004	Guillemot	✓	-	-	-	-
Netting height						
Mentjes and Gabriel., 1999	Sea ducks	X	X	-	-	-
Headline Drops						
Currently no studies quantifying these techniques						
Altered float lines						
Currently no studies quantifying these techniques						
Hanging ratio						
Mentjes and Gabriel., 1999	Ducks	X	X	-	-	-

Bycatch reduction program	Study species	Bycatch reduced?	No effect on target catch	Is there no effect on non-target catch?	Was there no impact on fishing effort?	Is the measure economically viable for fisheries?
Weights						
Erdmann *et al.*, 2005	Seabirds	✓	X	-	-	-
Net operations						
Setting and hauling times						
Melvin *et al.*, 1999	Guillemot Rhinoceros auklet	✓	X	-	-	-
Mentjes and Gabriel., 1999	Sea ducks	X	X	-	-	-
Training fishers to remove tangled birds						
Quayle 2015	Guillemot Razorbill	✓	-	-	-	-
Net sensors (alarm, light)						
Currently no studies quantifying these techniques						
Operational fishing measures						
Fisheries closures						
Regular *et al*. 2013	Guillemot	✓	-	-	-	-
	Herring gull	X	-	-	-	-
Gear switching						
Mentjes and Gabriel., 1999 (switching to longlines in	Sea ducks	✓	-	-	-	-

Bycatch reduction program	Study species	Bycatch reduced?	No effect on target catch	Is there no effect on non-target catch?	Was there no impact on fishing effort?	Is the measure economically viable for fisheries?
German Baltic Sea)						
Vetemaa and Ložys, 2009 (Switching to longlines in eastern Baltic Sea)	Seal and seabirds	✓	-	-	-	-
Vetemaa and Ložys, 2009 (switching to herring trap nets in Lithuania)	Seal and seabirds	✓	-	-	-	X
Bellebaum *et al.*, 2013 (switching to baited pots for cod in German Baltic Sea)	Seabirds	✓	-	-	-	-
Koschinski and Strempel, 2012 (switching to baited pots)	Seabirds and marine mammals	✓	X	-	-	-

8 Appendix references

Almeida, A., Ameryk, A., Campos, B., Crawford, R., Krogulec, J., Linkowski, T., Mitchell, R., Mitchell, W., Oliveira, N., Oppel, S. and Tarzia, M. (2017), 'Study on mitigation measures to minimise seabird bycatch in gillnet fisheries'. https://op.europa.eu/en/publication-detail/-%20/publication/f426200b-1138-11e8-9253-01aa75ed71a1/language-en [Accessed January 2023].

Armstrong, J. L., Brown, L. M., Fox, D. A. and Milliken, H. (2013), 'Gillnet configurations and their impact on Atlantic sturgeon and marine mammal bycatch in the New Jersey monkfish fishery', In: NMFS (ed) Workshop on sea turtle and Atlantic sturgeon bycatch reduction in gillnet fisheries, Jan 22–23, 2013, National Marine Fisheries Service and Atlantic States Marine Fisheries Commission.

Bærum, K. M., Anker-Nilssen, T., Christensen-Dalsgaard, S., Fangel, K., Williams, T. and Vølstad, J. H. (2019), 'Spatial and temporal variations in seabird bycatch: Incidental bycatch in the Norwegian coastal gillnet-fishery', PLoS ONE, 14: 0212786.

Baker, G. B. and Candy, S. G. (2014), 'Proof of concept experiment to demonstrate the efficacy of the 'Smart Tuna Hook'', Report prepared for AHI Enterprises by Latitude 42 Consultants. Kettering, Tasmania.

Barrington, J. H. S., Robertson, G. and Candy, S. G. (2016a), 'Categorising branch line weighting for pelagic longline fishing according to sink rates', Seventh Meeting of the Seabird Bycatch Working Group, ACAP, La Serena, Chile.

Barrington, J. H. S. (2016b), ''Smart Tuna Hook' as best practice seabird bycatch mitigation in pelagic longline fisheries', Seventh Meeting of the Seabird Bycatch Working Group, ACAP, La Serena, Chile.

Bielli, A., Alfaro-Shigueto, J., Doherty, P. D., Godley, B. J., Ortiz, C., Pasara, A., Wang, J. H. and Mangel, J. C. (2020), 'An illuminating idea to reduce bycatch in the Peruvian small-scale gillnet fishery', Biological Conservation, 241: 108277.

Boggs, C. H. (2001), 'Deterring albatrosses from contacting baits during swordfish long-line sets', Alaska Sea Grant, Fairbanks, 79 – 94.

Bordino, P., Mackay, A. I., Werner, T. B., Northridge, S. P. and Read, A. J. (2013), 'Franciscana bycatch is not reduced by acoustically reflective or physically stiffened gillnets', Endangered Species Research, 21, 1-12.

Brothers, N., Foster, A. and Robertson, G. (1995), 'The influence of bait quality on the sink rate of bait used in the Japanese longline tuna fishing industry: an experimental approach', CCAMLR Science, 2: 123–129.

Carretta, J. V. and Chivers, S. J. (2004), 'Preliminary estimates of marine mammal mortality and biological sampling of cetaceans in California gillnet fisheries for 2003', Scientific Committee Paper SC/56/SM1, International Whaling Commission.

Clark, B., Vigfúsdóttir, F., Jessopp, M., Burgos, J., Bodey, T. and Votier, S. (2019), 'Gannets are not attracted to fishing vessels in Iceland—potential influence of a discard ban and food availability', ICES Journal of Marine Science, 77/2: 692-700.

Claudino dos Santos, R., Silva-Costa, A., Sant'Ana, R., Gianuca, D., Yates, O., Marques, O. and Neves, T. (2016), 'Comparative trails of Lumo Leads and traditional line weighting in the Brazilian pelagic long-line fishery', Seventh Meeting of the Seabird Bycatch Working Group, ACAP, La Serena, Chile.

Cocking, L. J., Double, M. C., Milburn, P. J. and Brando, V. E. (2008), 'Seabird bycatch mitigation and blue dyed bait: A spectral and experimental assessment', Biological Conservation 141: 1354–1364.

Dagys, M., & Žydelis, R. (2002), 'Bird bycatch in fishing nets in Lithuanian coastal waters in wintering season 2001–2002', Acta Zoologica Lituanica, 12: 276-282.

Domingo, A., Jiménez, S., Abreu, M., Forselledo, R. and Pons, M. (2011), 'Effectiveness of tori-line use to reduce seabird bycatch in the Uruguayan pelagic long-line fleet', Sixth Meeting of ACAP Advisory Committee. Guayaquil, Ecuador, 29 August – 2 September 2011.

Erdmann, F., Bellebaum, J., Kube, J. and Schulz, A. (2005), 'Verluste von See- und Wasservögeln durch die Fischerei unter besonderer Berücksichtigung der international bedeutsamen Rast-, Mauser- und Überwinterungsgebiete in den Küstengewässern Mecklenburg-Vorpommerns', Landesamt für Umwelt, Naturschutz und Geologie Mecklenburg-Vorpommern, Güstrow, Germany, 129.

Field, R., Crawford, R., Enever, R., Linkowski, T., Martin, G., Morkunas, J., Morkune, R., Rouxel, Y. and Oppel, S. (2019), 'High contrast panels and lights do not reduce bird bycatch in Baltic Sea gillnet fisheries', Global Ecology and Conservation, 18: 00602.

Gianuca, D. Peppes, F. V., César, J. H., Sant'Ana, R. and Neves, T. (2013), 'Do leaded swivels close to hooks affect the catch rate of target species in pelagic long-line? A preliminary study of southern Brazilian fleet', Agreement on the Conservation of Albatrosses and Petrels, Fifth Meeting of the Seabird Bycatch Working Group. La Rochelle, France, 1–3 May 2013, SBWG5 Doc 33.

Gilman, E., Brothers, N. and Kobayashi, D. (2007), 'Comparison of the efficacy of three seabird bycatch avoidance methods in Hawaii pelagic longline fisheries', Fisheries Science, 73: 208–210.

Gilman, E., Chaloupka, M., Peschon, J. and Ellgen, S. (2016), 'Risk Factors for Seabird Bycatch in a Pelagic Longline Tuna Fishery', PLoS ONE 11/5: 0155477.

Hanamseth, R., Baker, G. B., Sherwen, S., Hindell, M. and Lea, M. A. (2017), 'Assessing the importance of net colour as a seabird bycatch mitigation measure in gillnet fishing', Aquatic Conservation: Marine and Freshwater Ecosystems, 28: 175-181.

Hayase, S. and Yatsu, A. (1993), 'Preliminary report of a squid subsurface driftnet experiment in the North Pacific during 1991', North Pacific Commission Bulletin, 53, 557-576.

Jiménez, S., Domingo, A., Abreu, M., Forselledo, R., and Pons, M. (2013), 'Effect of reduced distance between the hook and weight in pelagic long-line branchlines on seabird attack and bycatch rates and on the catch of target species', Agreement on the Conservation of Albatrosses and Petrels, Fifth Meeting of the Seabird Bycatch Working Group. La Rochelle, France, 1–3 May 2013, SBWG5 Doc 49.

Jiménez, S., Domingo, A., Winker, H., Parker, D., Gianuca, D., Neves, T., Coelho, R., and Kerwath S. (2020), 'Towards mitigation of seabird bycatch: Large-scale effectiveness of night setting and Tori lines across multiple pelagic longline fleets', Biological Conservation, 247: 108642.

Kiyota, M., Minami, H. and Takahashi, M. (2001), 'Development and tests of water jet devices to avoid incidental take of seabirds in tuna long-line fishery', CCSBT ERS-0111-63.

Klaer, N. and Polacheck, T. (1998), 'The influence of environmental factors and mitigation measures on by-catch rates of seabirds by Japanese longline fishing vessels in the Australian region', Emu-Austral Ornithology, 98/4: 305-316.

Løkkeborg, S. (2011), 'Best practices to mitigate seabird bycatch in long-line, trawl and gillnet fisheries - efficiency and practical applicability', Marine Ecology Progress Series, 435: 285–303.

Løkkeborg, S. and Robertson, G. (2002), 'Seabird and longline interactions: effectiveness of a bird-scaring streamer line and line shooter on the incidental capture of northern fulmars Fulmarius glacialis', Biological Conservation, 106: 359-364.

Mangel, J. C., Alfaro-Shigueto, J., Wang, J., Swimmer, Y. and Wallace, G. (2014), 'Tests of visual cues and subsurface nets as bycatch mitigation measures in small-scale gillnet fisheries in Peru', ACAP SBWG6 Doc 16. ACAP, Hobart.

Mangel, J. C., Wang, J., Alfaro-Shigueto, J. Pingo, S., Jimenez, A., Carvalho, F., Swimmer, Y. and Godley, B. (2018), 'Illuminating gillnets to save seabirds and the potential for multi-taxa bycatch mitigation', Royal Society Open Science, 5: 180254.

Manly, B. F. J. (2007), 'Incidental take and interactions of marine mammals and birds in the Kodiak Island salmon set gillnet fishery, 2002 and 2005', Final Report to NMFS Alaska Region, Western EcoSystems Technology, Cheyenne, USA.

Melvin, E. F., Parrish, J. K. and Conquest, L. L. (1999), 'Novel tools to reduce seabird bycatch in coastal gillnet fisheries', Conservation Biology, 13: 1386-1397.

Melvin, E. F., Dietrich, K. S., Fitzgerald, S. and Cardoso, T. (2011), 'Reducing seabird strikes with trawl cables in the pollock catcher-processor fleet in the eastern Bering Sea', Polar Biology, 34: 215-226.

Melvin, E. F., Guy, T. J. and Read, L. B. (2014), 'Best practice seabird bycatch mitigation for pelagic longline fisheries targeting tuna and related species', Fisheries Research, 149: 5-18.

Mentjes, T. and Gabriel, O. (1999), 'Fangtechnische Möglichkeiten zur Reduzierung des Beifangs von Meeresenten in der Dorschfischerei mit stationären Fanggeräten, (In German with English summary: Technical possibilities to reduce duck bycatches in winter cod fishery with static gear)', Informationen für die Fischwirtschaft aus der Fischereiforschung, 46: 36–41.

Ørsted. (2021), 'Volume B2, Annex 8.1: Compensation measures for FFC SPA: Bycatch Reduction: Ecological Evidence'. https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010098/EN010098-000511-B2.8.1%20RP%20Volume%20B2%20Annex%208.1%20Compensation%20measures%20for%20FFC%20SPA%20Bycatch%20Reduction%20Ecological%20Evidence.pdf [Accessed January 2023].

Ørsted. (2022), 'Compensation measures for FFC SPA: Guillemot and Razorbill Bycatch Reduction: Roadmap'. https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010098/EN010098-002040-Hornsea%20Project%20Four%20-%20Other-%20B2.8.2%20Compensation%20measures%20for%20FFC%20SPA%20Guillemot%20and%20Razorbill%20Bycatch%20Reduction%20Roadmap.pdf [Accessed January 2023].

Parker, G. C. (2017), 'Stocktake of measures for mitigating the incidental capture of seabirds in New Zealand commercial fisheries', Report to Southern Seabird Solutions Trust by Parker Conservation, Dunedin.

Pierre, J. P. and Norden, W. S. (2006), 'Reducing seabird bycatch in longline fisheries using a natural olfactory deterrent', Biological Conservation 130: 406–415.

Price, B., and Van Salisbury, C. (2007)' Low-Profile Gillnet Testing in the Deep Water Region of Pamlico Sound, NC', Completion Report For Fishery Resource Grant: 06-FEG-02 ESA Scientific Research Permit # 1563.

Quale, H. (2015), 'Filey Bay: Safe Seas for Seabirds December 2015'. https://www.rspb.org.uk/globalassets/downloads/documents/campaigning-for-nature/casestudies/rspb-filey-bay-safe-seas-for-seabirds-2015-report.pdf [Accessed January 2023].

Regular, P. M., Montevecchi, W., Hedd, A., Robertson, G. and Wilhelm, S. (2013), 'Canadian fishery closures provide a large-scale test of the impact of gillnet bycatch on seabird populations', Biology Letters, 9: 20130088.

Robertson, G., Candy, S. G., Wienecke, B. and Lawton, K. (2010), 'Experimental determinations of factors affecting the sink rates of baited hooks to minimize seabird mortality in pelagic long-line fisheries', Aquatic Conservation: Marine and Freshwater Ecosystems, 20: 632–643.

Robertson, G., Candy, S. G. and Hall, S. (2013), 'New branch line weighting regimes to reduce the risk of seabird mortality in pelagic longline fisheries without affecting fish catch', Aquatic Conservation: Marine and Freshwater Ecosystems, 23/6: 885-900.

Robertson, G., Ashworth, P., Ashworth, P., Carlyle, I. and Candy, S. G. (2015), 'The development and operational testing of an underwater bait setting system to prevent the mortality of albatrosses and petrels in pelagic longline fisheries', Open Journal of Marine Science, 5/01:1.

Rouxel, Y., Crawford, R., Cleasby, I. R., Kibel, P., Owen, E., Volke, V., Schnell, A. K. and Oppel, S. (2021), 'Buoys with looming eyes deter seaducks and could potentially reduce seabird bycatch in gillnets', Royal Society Open Science, 8: 210225.

Sullivan, B. J., Kibel, B., Kibel, P., Yates, O., Potts, J. M., Ingham, B., Domingo, A., Gianuca, D., Jimenez, S., Lebepe, B., Maree, B. A., Neves, T., Peppes, F., Rasehlomi, T., Silva-Costa, A. and Wanless, R. M. (2017), 'At-sea trialling of the Hookpod: a 'one-stop' mitigation solution for seabird bycatch in pelagic longline fisheries', Animal Conservation, 21: 159-167.

Trippel, E. A., Holy, N. L., Palka, D. L., Shepherd, T. D., Melvin, G. D. and Terhune, J. M. (2003), 'Nylon barium sulphate gillnets reduce porpoise and seabird mortality', Marine Mammal Science, 19: 240-243.

Wang, J. H., Fisler, S. and Swimmer, Y. (2010), 'Developing visual deterrents to reduce sea turtle bycatch in gill net fisheries', Marine Ecology Progress Series, 408: 241-250.

Wark, K., Fox, D., Milliken, H. and Armstrong, J. (2013), 'Overview of bycatch reduction research for sturgeon, or similar fish morphologies', In: NMFS Workshop on sea turtle and Atlantic sturgeon bycatch reduction in gillnet fisheries. Jan 22–23, 2013. National Marine Fisheries Service and Atlantic States Marine Fisheries Commission.