Marine Management Organisation

Stage 4 Fishing Gear MPA Impacts Evidence: Marine Birds

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Contents

Executive summary

This document collates and analyses the best available evidence on the impacts of commercial fishing on marine protected area (MPA) marine bird features. This document will inform site level assessments of the impact of fishing on MPAs as part of Stage 4 of the Marine Management Organisation’s work to manage fishing in MPAs.

Direct and indirect impacts from various types of fishing gear (bottom towed gear, midwater gear, anchored nets and lines, traps) and the presence of fishing vessels have the potential to impact MPA bird features. For each MPA, a site level assessment considering the site conservation objectives, intensity of fishing activity taking place and exposure to natural disturbance will be completed to determine whether management will be required.

1 Introduction

The Marine Management Organisation (MMO) is the principal regulator for England's seas, including leading the assessment and management of fishing in marine protected areas (MPAs) offshore of 6 nautical miles (nm)[1].

This document forms part of MMO's Stage 4 work to achieve the government's aim of having appropriate fisheries management measures in place for all offshore MPAs in English waters by the end of 2024. It is one of a suite of documents which focus on the interaction of fishing gear on particular designated features, and it will support the delivery of site level assessments.

This document describes the impact of commercial fishing gears on protected marine bird species (a designated feature within certain MPAs). It describes the potential for pressures and impacts caused by fishing on marine birds by gathering and analysing the available evidence for gear-feature interactions.

There are three MPAs designated to protect marine birds within MMO's jurisdiction:

- Greater Wash MPA;
- Liverpool Bay MPA; and
- Outer Thames Estuary MPA.

The Stage 4 Call for Evidence Introduction available on our survey page[2] provides further background information and details of other documents produced.

1.1 Key definitions

A separate glossary in the Stage 4 Call for Evidence Introduction[2] includes the important terms used in this document. Wherever possible these are taken from Natural England's Glossary of terms used within conservation advice packages (CAPs).

The following terms are particularly key when reading this document. Figure 1 also visually demonstrates the sensitivity of MPA features to pressures.

Habitat - the place in nature where a plant or animal normally lives and grows.

Species - a set of animals or plants in which the members have similar characteristics to each other.

Designated feature ('feature') - a species, habitat, geological or geomorphological entity for which an MPA is identified and managed.

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[1] Inshore fisheries and conservation authorities (IFCAs) are responsible for managing fishing in MPAs within 6 nm.
[2] https://consult.defra.gov.uk/mmo/stage-4-call-for-evidence

Sensitivity - The sensitivity of a feature (species or habitat) is a measure that is dependent on the ability of the feature (species or habitat) to resist change and its ability (time taken) to recover from change.

Pressure - the mechanisms through which an activity has an effect on a feature.

Impact - the consequence of pressures (such as habitat degradation) where a change occurs that is different to that expected under natural conditions.

Direct impacts - the impacts caused by direct interaction between marine birds and the fishing gear/activity (for example physical injury through vessel collision and entanglement in fishing gear, or behaviourally mediated impacts, such as changes in foraging/breeding behaviour in response to a pressure as might occur through acoustic or visual disturbance from vessel operations).

Indirect impacts - the impacts caused to marine birds by the interaction of the fishing gear/activity having a direct impact upon another connected habitat and/or associated species.

Removal of non-target species - the unintended removal of a designated feature or species directly related to the integrity of the feature, in this case marine bird species. This is referred to as marine bird bycatch going forward.

Removal of target and non-target prey species - both the intended and unintended removal of a designated feature or species directly related to the integrity of the feature, in this case marine bird prey species.

Physical loss, change or damage to supporting habitat - impacts to the habitat of the species focused on, in this case marine birds. This may include the following pressures caused by fishing:

- abrasion/disturbance of the substrate on the surface of the seabed;
- penetration and/or disturbance of the substratum below the surface of the seabed, including abrasion;
- physical change (to another sediment type);
- smothering and siltation rate changes (light).

Bycatch – the removal of species not targeted by the fishery, in this case, the incidental killing and capture of marine birds. The pathways for marine bird bycatch may include capture in fishing gear and collision or entanglement with deployed gear or gear that is being deployed/hauled. Water column feeders may be at risk from bycatch during foraging trips.

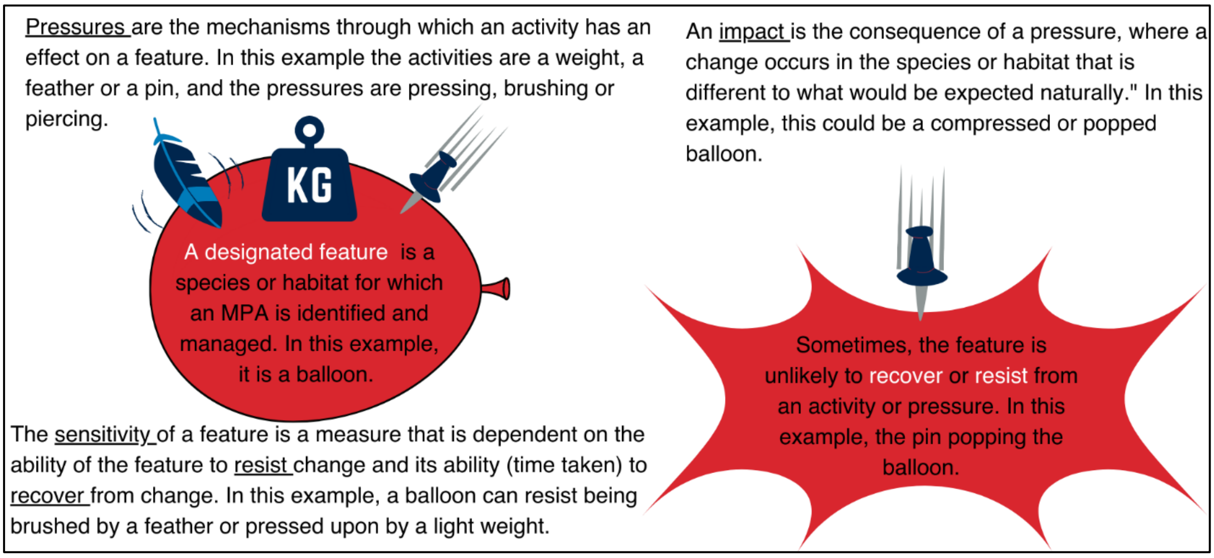

Figure 1. Definitions related to MPA pressures and impacts.

1.2 Structure of this document

Section 2 describes the types of fishing gears considered in this document.

Section 3 describes the MPA features considered and references the evidence sources used in this document.

Sections 4 to 8 describe the available evidence regarding the pressures resulting from the fishing gears or fishing vessel presence on different marine bird MPA features.

Section 9 provides information on the levels of literature, caveats and assumptions for the evidence included in this document.

Section 10 provides information on variation in impacts.

Annex 1 provides information on the pressures and sensitivities of features covered in this document. The tables identify which pressures are discussed within this review and include justification for those that are not.

2 Overview of fishing gears

This section describes the different types of fishing gear that are considered in this document due to their potential to interact with marine birds:

- Bottom towed gear
- Midwater gear
- Anchored nets and lines
- Traps

Each sub-type of the gear types listed above may have different impacts on marine birds, where possible analysis of the impact of these gears will take these differences into account. Further information on fishing gears and how they interact with the seabed and other MPA features can be found in the following documents:

- Stage 3 Fishing Gear MPA Impacts Evidence Bottom Towed Gear document[3]
- Stage 3 Fishing Gear MPA Impacts Evidence Anchored Nets and Lines document[3]
- Stage 3 Fishing Gear MPA Impacts Evidence Traps document[3]

Fishing vessel presence is included as a separate section to incorporate pressures that are not necessarily specific to one gear type (for example, collision risk).

Further information regarding different fishing gear types can also be found in the classification and illustrated definition of fishing gears produced by the Food and Agriculture Organization of the United Nations (FAO) (He et al., 2021).

2.1 Bottom towed gear

Bottom towed fishing gear means any trawls, seines, dredges or similar gear, including trawls towed on or very close to the seabed, which are actively moved in the water by one or more fishing vessels or by any other mechanised system and in which any part of the gear is designed and rigged to operate on, and be in contact with, the seabed.

In this document bottom towed gear includes the following fishing gear types:

- dredges: boat dredges, mechanized dredges
- demersal seines: Danish or anchor seines, pair seines, Scottish seines
- bottom trawls: otter trawls, beam trawls, Nephrops trawls, pair trawls, twin trawls and semi-pelagic trawls.

The target species will depend on the type of bottom towed fishery. In general, (Montgomerie, 2022) noted that bottom trawls can target species such as soles, plaice, haddock, cod, whiting, monkfish and Nephrops; whereas, beam trawls will typically target soles, plaice, shrimp, skate, cuttlefish with megrims and monkfish in deeper waters; and scallop dredges target queen scallops, oysters and mussels. The main target species in the UK are demersal species, as well as specifically cuttlefish, dover sole, haddock, monkfish, Nephrops, shrimp and squid (Seafish, 2023a). In addition, the levels of non-target prey species removal will vary depending on the type of fishery and the gears in use.

[3] Stage 3 Fishing Gear Impacts Evidence Documents https://www.gov.uk/government/publications/marine-protected-areas-stage-3-impacts-evidence Last accessed: 24/08/2023

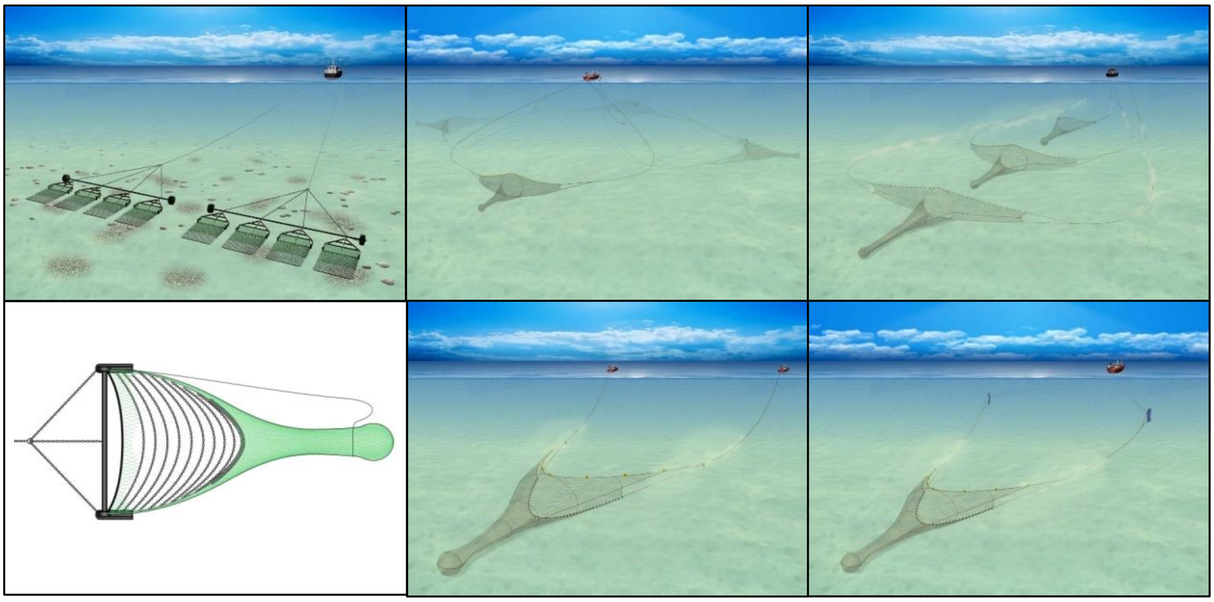

Figure 2. Dredges (top left), anchor seine (top middle), Scottish seine (top right), beam trawl (bottom left), pair trawl (bottom middle), semi-pelagic trawl (bottom right). © Seafish

2.2 Midwater gear

Midwater gear includes midwater towed gear and purse seines in this review.

Midwater towed gear (also known as pelagic gear) refers to fishing gear where trawls are towed at any point in the water column between the seabed and the surface (Montgomerie, 2022). Midwater trawls are usually much larger than bottom trawls and consist of cone-shaped bodies made up of four panels ending in a narrowed terminal section (the cod end) where the fish are retained (FAO, 2023c).

There are multiple types of midwater trawls including:

- Single trawls – where the net is towed by one vessel using a set of mid-water doors to open the net horizontally (Montgomerie, 2022).
- Pair trawls – where the net is towed by two vessels and the horizontal opening is set by the distance between the two vessels (Montgomerie, 2022).

The position of the gear in the water column can vary, being controlled by factors such as the vessels speed (Montgomerie, 2022). A wide range of vessel sizes are able to utilise these gears. For example, vessels can be 10 metres (m) to 40-80 m in length, the largest of these vessels can have the ability to freeze their catch on board and are capable of removing larger volumes of fish per tow; due to the ability to use larger nets.

Purse seines are included in this category for the purpose of this review. A purse seine is a large net shot in a circle to surround a shoal of fish, forming a curtain of netting in the water (Montgomerie, 2022). A cable running around the lower edge of the net is hauled in causing the bottom of the purse seine to close, and forming a bowl-like shape containing the fish (Montgomerie, 2022).

Midwater gears are generally used to target pelagic shoaling species (Montgomerie, 2022). The main target species of midwater gears in the UK are blue whiting, anchovy, herring, mackerel and scad (Seafish, 2023e).

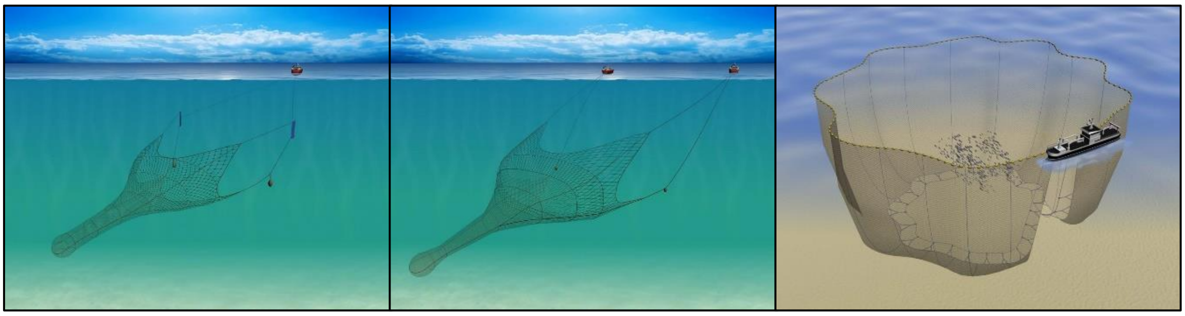

Figure 3. Midwater single trawl (left), midwater pair trawl (middle), purse seine (right). © [Seafish]

2.3 Anchored nets and lines

This section describes the different types of fishing gear which are considered in this document under the broad group of anchored nets and lines.

2.3.1 Nets

This review uses 'gillnet' as a collective term for static gear that uses gilling or entangling meshes to trap fish.

The term gillnet is a generic name for many different styles of nets (which may be referred to by different names depending on the fishery) and is also a specific net style itself (Montgomerie, 2022). In broad terms, gillnets are curtains of fine netting that are hung in the water (Montgomerie, 2022), which fish swim into and become gilled (i.e., it's gills become caught in the net) or entangled (where part or the whole of the body become entangled) (FAO, 2023a). Different types of gillnets may be combined, and the nets can be deployed alone or, as it more usual, deployed in a line in large numbers known as fleets (FAO, 2023a). Gillnets may be anchored to the seabed (i.e., bottom-set nets) or allowed to drift with the tide or connected with the vessel (i.e., drift nets) (FAO, 2023a; Montgomerie, 2022).

The specific style of net that the term 'gillnet' may refer to consists of single layers of netting weighted to the seabed, which are supported by floats allowing the net to hang vertically in the water column (Montgomerie, 2022). The main target species in the UK for such single-walled gillnets are demersal species, as well as specifically cod, dogfish, haddock, hake, megrims, monkfish, pollack and skate (Seafish, 2023b).

Trammel nets

Trammel nets are type of gillnet that consist of three layers of netting, wherein a slack inner net with a small mesh size is sandwiched between two layers of larger mesh netting (Montgomerie, 2022; FAO, 2023c). Fish swim through the first outer layer of large mesh, and then get entangled between the layers (Montgomerie, 2022). Trammel nets can catch and retain a broader range of species and fish sizes relative to a single-walled gillnets (Montgomerie, 2022), with the main target species in the UK being brill, cod, dover sole, flats, haddock, hake, monkfish and pollack FAO, 2023c).

Tangle nets

Tangle nets consist of a single wall of netting, wherein the net is hung onto ropes to create a large amount of slack netting (Seafish, 2023g). Due to having less flotation, tangle nets generally do not stand as high off the seabed as the average gillnet (Seafish, 2023g). The loose netting allows bottom-living species to be retained (for example flatfish monkfish and shellfish) that due to their body shape might not get as easily caught in a standard gillnet (Montgomerie, 2022). As per other gillnet types, tangle nets are rigged with mesh sizes and slack to suit the target species but tend to be rigged with stronger and larger mesh, allowing larger fish to be trapped without causing net damage (Montgomerie, 2022). The main target species of tangle nets in the UK are brill, dover sole, monkfish, plaice, skates, spider crabs and turbot (Seafish, 2023g).

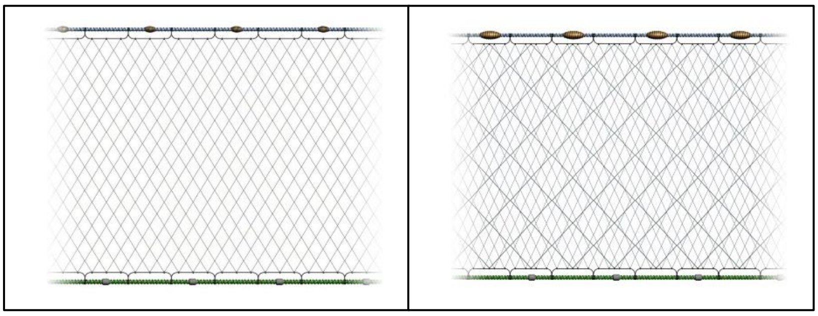

Figure 4. Single walled gill net (left), trammel net (right). © Seafish

2.3.2 Lines

Lines refers to gear where the fish are attracted by natural or artificial bait (lures) placed on hooks at the end of lines, upon which the fish then become caught (FAO, 2023b). There are multiple types of line fishing including:

- Longlining - where multiple hooks are on one line, and the lines are either set on the seabed (demersal longlines) or in specific positions in the water column (pelagic longlines).
- Jigging – where hooks with artificial lures are operated in a rhythmic up-down motion to attract and capture fish.
- Trolling – where basic lines are towed behind a boat, with each line having one or more hooks with natural bait or an artificial lure (Montgomerie, 2022).

The target species depends on the type of line fishery. For example, in the UK the main target species for longlines are any demersal species, as well as specifically bass, cod, dogfish, haddock, halibut, ling, pollack, saithe, skates and turbot (Seafish, 2023d). For jigging, the main target species are cod, mackerel, pollock, saithe and squid (Seafish, 2023c), and for trolling the target species tends to be bass and tuna (Seafish, 2023h).

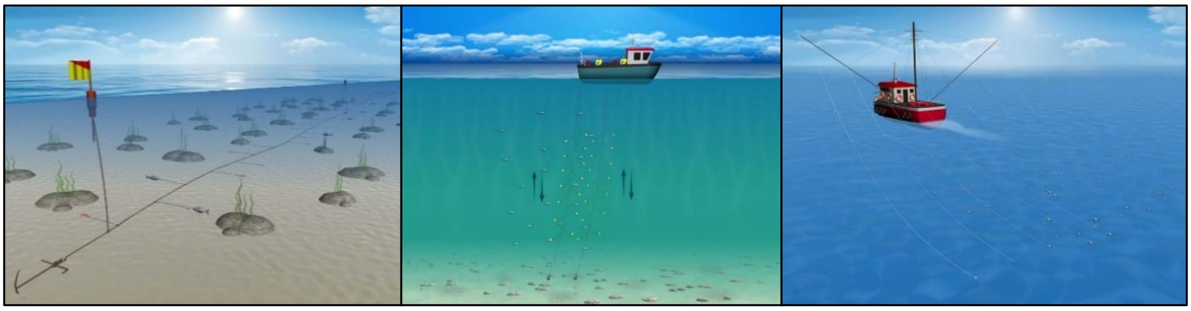

Figure 5. Longlining (left), jigging (middle), trolling (right)
© Seafish

2.4 Traps

Traps are stationary structures of many shapes and sizes into which fish and shellfish are drawn by bait or other attractants (He et al., 2021). A pot is a kind of trap, usually set on the sea floor, with a small enclosure that attracts species through one or more entrances allowing their entry but preventing or hindering their escape (He et al., 2021). The term 'trap' is used interchangeably with pot in the literature and by the fishing industry in many fisheries and in many locations. Smaller pots are also called 'creels' (He et al., 2021). The number of traps/fleets deployed, and soak times can vary. For example, small vessels may operate a couple of traps deployed by hand, whilst larger vessels may operate thousands (Montgomerie, 2022). The main target species of traps in the UK are brown crab (also known as edible crab), spider crab, velvet crab, cuttlefish, lobsters, Nephrops, prawns and whelks (Seafish, 2023f).

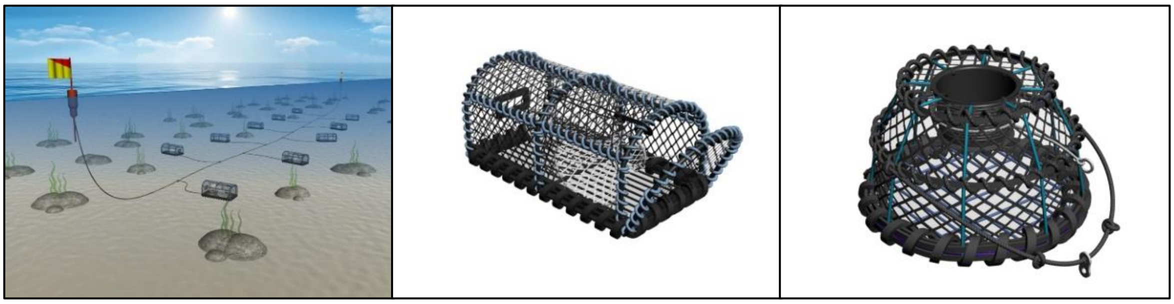

Figure 6. Pots on seabed (left), lobster pot (middle), inkwell pot – brown crab (right). © Seafish

2.5 Fishing vessel presence

The section on vessel presence incorporates pressures that are not necessarily specific to gear type and may occur from any fishing vessel. This includes pressures such as disturbance from underwater noise during vessel transit and death or injury through collision. Such pressures may be produced by all fishing vessels irrespective of gear type; hence, these pressures are considered in the general fishing vessel presence.

3 MPA features: marine birds

This document focuses on the interaction between commercial fishing and Annex I species under the Birds Directive (2009/147/EC) classified in Stage 4 MPAs (Greater Wash MPA, Liverpool Bay MPA and Outer Thames Estuary MPA). This includes six marine bird species as well as waterbird assemblage (hereafter referred to collectively as marine birds). The species are summarised in Table 1 with further detail provided in sections 3.1 to 3.7 below.

These marine birds have been identified as potentially sensitive to commercial fishing gears. These sensitivities were derived using advice from the Joint Nature Conservation Committee (JNCC) and Natural England and through review of the available scientific literature. Please see Annex 1 for a summary of the pressures of each gear type and vessel presence on the features described in this document and their associated sensitivities. Where a feature is potentially sensitive to a gear type or vessel presence (based on its resilience to the pressure and ability to recover) the interaction is considered in sections 4 to 10 below.

Table 1. Summary of MPA features (clupeids include herring and sprat; gadoids are species of the cod family including whiting, cod, poor cod and saithe).

MPA feature	Season	Relevant MPAs	Feeding	Prey items	Supporting habitats
Red-throated diver	Non-breeding season (Sept-April/ Oct-May)	Outer Thames Estuary, Greater Wash, Liverpool Bay	Pelagic and benthic diving	Sandeels, clupeids, gadoids, mackerel, flatfish	Circalittoral rock, intertidal sand and muddy sand, subtidal sediments
Sandwich tern	Breeding season (Apr-Aug)	Greater Wash,	Surface dipping and plunge diving	Sandeels, clupeids, gadoids, crustaceans, invertebrates	Sandy coastal areas and estuaries
Common scoter	Non-breeding season (Sept-Apr)	Greater Wash, Liverpool Bay	Diving in flocks	Molluscs, crustaceans, worms	Sandy seabed and offshore shallow areas
Little gull	Non-breeding season	Greater Wash,	Surface dipping or	Insects (summer), small fish and marine	Range of freshwater and saline

MPA feature	Season	Relevant MPAs	Feeding	Prey items	Supporting habitats
	(Aug-May)	Liverpool Bay	brief plunge-diving	invertebrates (winter)	wetlands (on migration)
Little tern	Breeding season (Apr-Aug)	Outer Thames Estuary, Greater Wash, Liverpool Bay	Surface dipping and plunge diving	Sandeels, clupeids, crustaceans, invertebrates	Intertidal sand and muddy sand
Common tern	Breeding season (Apr-Aug)	Outer Thames Estuary, Greater Wash, Liverpool Bay	Surface dipping and plunge diving	Sandeels, clupeids, gadoids, crustaceans, invertebrates.	Intertidal sand and muddy sand

3.1 Red-throated diver (*Gavia stellata)*, non-breeding season

Figure 7. Red-throated diver © 1186291699 Shutterstock.

The red-throated diver is the smallest diver species. Red-throated divers are highly mobile and may move between sandy bays, sandbanks and the mouths of estuaries, where water of different salinities mix (Dierschke et al., 2017; McGovern et al., 2016; Natural England and JNCC, 2013). Red-throated divers do not return to land during the non-breeding season, spending time rafting and fishing in shallow coastal waters (Dierschke et al., 2017; Natural England and JNCC, 2010). Red-throated divers are opportunistic and generalist feeders, diving below the surface to catch small fish at shallow depths (McGovern et al., 2016; Guse et al., 2009). They carry out both pelagic and benthic dives with an ability to vary foraging behaviour depending on habitat and prey availability (Duckworth et al., 2021).

Diet: Little is known about the diet of red-throated divers, particularly during the non-breeding season, but it is likely to include sandeels, clupeids (herring and sprat), gadoids (cod family), mackerel and flatfish (Guse et al., 2009; Natural England and JNCC, 2010; Natural England and JNCC, 2013).

Supporting habitats: may include areas of circalittoral rock, intertidal sand and muddy sand, subtidal coarse sediment, subtidal mixed sediments, subtidal mud and subtidal sand (Natural England and JNCC, 2021).

3.2 Sandwich tern (*Thallaseus sandvicensis*), breeding season

The Sandwich tern is a relatively large tern which mostly feeds on fish plunge diving (British Trust for Ornithology, 2021; RSPB, 2021), but they have also been observed surface dipping and picking during the breeding season, potentially for invertebrates (Eglington and Perrow, 2014; Wilson et al., 2014). Sandwich terns generally forage within 34.3 +/- 23.2 kilometres (km) of their breeding colony (Woodward et al., 2019).

Figure 8. Sandwich tern with sandeel © Natural England/Allan Drewitt 15 June 2016.

Diet: Predominantly sandeels and clupeids (herring and sprat), but may also feed on gadoids (cod family), crustaceans and invertebrates (British Trust for Ornithology, 2021; RSPB, 2021; Eglington and Perrow, 2014; Wilson et al., 2014).

Supporting habitats: Sandy coastal areas and estuaries (British Trust for Ornithology, 2021). Favoured nesting habitat includes low-lying offshore islands, islets in bays or brackish lagoons, spits or remote mainland dunes (JNCC, 2021a).

3.3 Common scoter (*Melanitta nigra*), non-breeding season

The common scoter is a dark seaduck which are often seen as large bobbing rafts offshore, or long straggling lines flying along the coast (RSPB, 2021). Common scoter feed by diving, usually synchronously in flocks (Natural England, 2012a). When diving to the seabed, common scoter remain submerged for a period of 30 to 50 seconds but can spend more time submerged in deep water (Kaiser et al., 2002).

Figure 9. Male common scoter © Natural England/JNCC.

Diet: Predominantly on bivalve molluscs (for example, mussels, cockles, clams, oysters) and a variety of other molluscs, crustaceans, and worms (Natural England, 2012a).

Supporting habitats: Exclusively marine outside of the breeding season, supporting habitats may include sandy seabed and offshore shallow areas (Sweet, 2008).

3.4 Little gull (*Hydrocoloeus minutus*), non-breeding season

The little gull is a small gull species. They catch food on or just below the water surface by flying low over the water followed by a surface-dip or brief plunge-dive into the water. They can also peck prey from the surface (Natural England, 2012b).

Figure 10. Little gull © Ronan McLaughlin.

Diet: Mostly insects in the summer and mostly small fish and marine invertebrates in the winter (British Trust for Ornithology, 2021). The small fish caught by little gulls are mostly small fry from the surface (Hayman and Hume, 2001).

Supporting habitat: Limited information is available about the specific habitat preferences of little gulls, particularly offshore (Natural England, 2012b). On migration, supporting habitats may include a range of freshwater and saline wetlands, including reservoirs, lakes, saline lagoons, estuaries and shallow inshore waters (Natural England, 2012b).

3.5 Little tern (*Sternula albifrons*), breeding season

The little tern is the UK's smallest tern species. They feed singly, in small parties or in widely scattered flocks in shallow water, often very close to the shoreline. Little tern plunge dive to catch their prey. (Eglington and Perrow, 2014). The principal foraging areas for little terns are shallow subtidal coastal waters, with limited foraging ranges from breeding colonies (mean of 5 km) (Woodward et al., 2019).

Figure 11. Little tern feeding young © 1986930695 Shutterstock.

Diet: Predominantly sandeels and clupeids (herring and sprat), but may also feed on crustaceans and invertebrates (Eglington and Perrow, 2014).

Supporting habitat: May include areas of intertidal sand and muddy sand (Natural England and JNCC, 2021).

3.6 Common tern (*Sterna hirundo*), breeding season

Figure 12. Common tern © Natural England/Rebecca Walker August 2014.

The common tern is a medium-sized tern (Eglington and Perrow, 2014). They are generalist and opportunistic feeders, feeding primarily on small fish and crustaceans in shallow coastal or estuarine waters (Eglington and Perrow, 2014). Common terns use a broad range of methods to catch prey, including dipping, kleptoparasitism (stealing from others) and plunge diving to a depth of 1-2 m (Eglington and Perrow, 2014). Common terns generally forage within 18.0 +/- 8.9 km of their breeding colony (Woodward et al., 2019).

Diet: Predominantly sandeels, clupeids (herring and sprat) and gadoids (cod family) (Wickliffe and Jodice, 2010; Eglington and Perrow, 2014), but may also feed on crustaceans and invertebrates.

Supporting habitat: May include areas of intertidal sand and muddy sand (Natural England and JNCC, 2021; Thaxter et al., 2012).

3.7 Waterbird assemblage

In the context of protected sites, the waterbird assemblage is a site-specific feature where there are a total of 20,000 or more waterbirds (as defined by the Ramsar Convention (JNCC, 2019)) within a site. It consists of all waterbirds present in the site. The scale of the assemblage is calculated as the sum of the individual species mean of peak estimates at a site. In addition to bird species listed as qualifying features of the site in their own right (qualifying under Stage 1.1 or 1.2 of the UK special protection area site selection guidelines (JNCC, 2021b)), there may be named species specifically listed as 'named main components of the assemblage' if present in sufficient numbers that they make up a substantial part of the assemblage, for example, if over 1% of the Great Britain population occurs or they occur with over 2,000 individuals. Waterbird assemblages are a designated feature of Liverpool Bay MPA only. Due to the site-specific nature of waterbird assemblages, impacts to these species will be covered in future site level assessments. It is assumed that the pressures identified for the species above will also apply to waterbird assemblages.

3.8 Prey species and supporting habitats

The spawning and nursery grounds of prey species are an important consideration when assessing the impacts of fishing on the supporting habitats of marine birds.

Prey species of marine birds are described in Table 3 and sections 3.1 to 3.6. Impacts to these supporting habitats may cause loss of foraging sites and reduction in food resources for marine birds. Red-throated divers are generalist feeders targeting a broad range of fish species and seem to target available prey rather than specialise, indicating that they may be less susceptible to impacts to prey availability (Guse et al., 2009). Tern species are particularly sensitive to prey availability due to their specialised diet, small foraging range, restricted foraging techniques and tight energy budget (Furness and Tasker, 2000; Dänhardt and Becker, 2011), as well as a potential reduction in breeding capability caused by changes in prey availability (Ponchon et al., 2019; Tasker et al., 2000; Goyert, 2014).

Spawning areas

Sprat, whiting, cod, poor cod and saithe spawn in the water column. Therefore, benthic impacts to the spawning grounds of these species are not relevant.

Herring and sandeels are benthic spawners (Runnström, 1941; Sparholt, 2015). Herring spawn in autumn or spring: spring-spawners lay their eggs inshore on a range of substrates, and autumn-spawners shed their eggs further offshore over gravel and coarse substrates (Runnström, 1941). Sandeels are dependent on sandy substrates habitats, on which they bury themselves at night and in which they lay their eggs in December and January (Macer, 1966; Gould, 1990). Therefore, benthic impacts on spawning grounds of herring and sandeels need to be considered for marine bird species which feed on them (red-throated diver, Sandwich tern, little tern and common tern).

Nursery areas

In general, juvenile gadoids (including whiting, cod, poor cod and saithe) use shallow coastal areas which offer refuge and protection from predation (Kamenos et al., 2004). Juvenile sprat and herring are also generally associated with inshore areas including large bays and estuaries (Ellis et al., 2012). Therefore, consideration of benthic impacts to nursery areas for gadoids, sprat and herring in MPAs offshore of 6 nm, where MMO is the regulator, is not considered to be required.

After hatching, sandeel larvae drift in the currents before settling into the seabed once they are around three months old around February to May, likely using similar habitats that they require as adults (Wright and Bailey, 1996). In the UK, juvenile sandeels have been found to be present in a range of areas offshore (Ellis et al., 2012). Therefore, benthic impacts on nursery grounds of sandeels need to be considered for marine bird species which feed on them (red-throated diver, Sandwich tern, little tern and common tern).

4 Bottom towed gear

This section brings together and analyses the available evidence on how bottom towed gear affects marine birds. As a result of bottom towed gear, marine birds may be sensitive to the following pressures, which are considered in this document:

Direct impacts

- marine bird bycatch (removal of non-target species);

Indirect impacts

- removal of target and non-target prey species;
- changes in suspended solids (water clarity);
- physical loss, change or damage to supporting habitat.

4.1 Direct impacts

4.1.1 Marine bird bycatch

Bottom trawls

Bottom trawls may cause harm to or mortality of marine birds through collision with cables or warps running from the vessel to the net or through entanglement in the net itself (Ellis et al., 2013). Between 2015 and 2016, Sigourney et al. (2019) recorded marine bird bycatch from four types of commercial fishing gear in the northeast and mid-Atlantic. A total of 655 birds were bycaught from all gears and 9 birds were bycaught in bottom trawls during 388.3 days observed fishing effort (Sigourney et al., 2019). Other gear types observed included gillnets, sea scallop dredges and paired midwater trawls (Sigourney et al., 2019). The bottom trawl bycaught individuals did not include species in this review; 10 were gull species (*Larus marinus, Larus smithsonianus*), other species included shearwaters and gannets (Sigourney et al., 2019). Great northern and red-throated divers were not caught from bottom trawls (Sigourney et al., 2019). Ellis et al. (2013) reported very few marine birds as bycatch in bottom otter trawl fisheries in the Maritimes, with 8 to 19 individuals caught per year between 2002 and 2008. Predominant species did not include those covered in this review nor species within the same functional group, instead they comprised of mostly shearwaters, gannets and cormorants (Ellis et al., 2013). A study by ICES (2013) reported bycatch from bottom trawls in north east Atlantic European waters which similarly did not include the species in this review - European shag, gulls and guillemots were bycaught in addition to the species reported by Ellis et al. (2013). Watkins et al. (2008) reported high attendance of gull species (*Larus dominicanus* and *Larus sabini*) with an average maximum of 61 individuals present when trawls were dumping waste. During 190 hours of trawl observations, no mortalities were recorded but there were ten light collisions and three heavy collisions for gull species (Watkins et al., 2008). For tern species (*Sterna* spp.), low attendance at trawls was reported with no mortalities or collisions (Watkins et al., 2008).

Some studies suggest that bottom trawlers aren’t known to take high numbers of marine birds, with reports of no to minimal bycaught marine birds during trawl operations (RSPB, no date). Preliminary estimates of bird bycatch by UK vessels in UK and adjacent waters by Northridge et al. (2020) did not include analysis of bycatch data from bottom trawls due to relatively low observations. On-board observations of Portuguese mainland fisheries recorded no captured marine birds from bottom trawling on 92 vessels over an estimated 514 trips (Oliveira et al., 2015). It is thought that fewer divers are bycaught due to their tendency to fly away from fishing vessels (ICES, 2018) and because they are more widely dispersed compared to species that feed in large aggregations (Jarrett et al., 2017). Despite scoter being predicted as being one of the most sensitive species to bycatch by fishing gears used at depth near the seabed by Bradbury et al. (2017), bycatch of common scoter by bottom trawls is not well documented in the literature.

Demersal seines

There is minimal evidence for the impacts of demersal seines on marine birds through bycatch, for example, the UK Bycatch Monitoring Programme did not assess this gear type (Northridge et al., 2020). The Department of Fisheries and Oceans Fisheries Observer Program in Canada reported no marine bird species as bycatch from various seine gears from 1998 to 2008 (excluding purse seines) (Ellis et al., 2013).

Dredges

Some studies report marine bird bycatch in dredges, for example, Sigourney et al. (2019) recorded 21 marine birds bycaught in sea scallop dredges over 687.9 days observed fishing effort. Species bycaught did not include those covered by this review but included great black-backed gull, great shearwater, herring gull and Northern gannet (Sigourney et al., 2019). This study contrasts to findings of earlier studies and conclusions that dredges are unlikely to pose a bycatch risk for marine birds (Harrington and Stram, 2005; Ellis et al., 2013; Rowe, 2013), for example, Harrington and Stram (2005) noted no reported takes of marine birds in Alaskan scallop fisheries and Ellis et al. (2013) reported no marine bird species as bycatch from dredges in Canada during the Department of Fisheries and Oceans Fisheries Observer Program from 1998 to 2008. Deep diving marine bird species are reported to be the most sensitive to bycatch from gears used in deep water near the seabed (Bradbury et al., 2017); species covered within this review are not know to be deep diving indicating a lower risk. There is minimal evidence to suggest that dredges pose a bycatch risk for the species covered in this review, UK bycatch studies have not focused on dredges as a gear type of concern (Northridge et al., 2020).

4.2 Indirect impacts

4.2.1 Removal of target and non-target prey species

Bottom towed gear may cause the removal, harm, or mortality of marine bird prey species. Prey may be target species of fisheries, non-target bycatch or species harmed but not removed by fishing operations. This may cause a direct or indirect reduction in food availability for overwintering and breeding marine birds (Natural England, 2012a; Jarrett et al., 2017).

Bottom trawls

Small mesh bottom trawls may target sandeels which are the preferred species for a wide range of marine birds, including red-throated divers and tern species (Furness and Tasker, 2000; Green, 2017). Whilst the generalist feeding strategy of red-throated divers reduces the potential impact, tern species may be particularly sensitive to prey availability (see Section 3.8 for details). Preliminary ICES results from 2020 estimated sandeel catches of 105,928 and 19,707 tonnes in the central and southern North Sea and the northern and central North Sea respectively (ICES, 2021b, 2021a). Spatial and temporal overlap of marine birds and sandeel fisheries is important to consider when assessing impacts (Tasker et al., 2000). Declines in sandeel populations in the North Sea have been indicated in the diets of guillemots, with lower proportions of sandeels in diets also coinciding with reduction in breeding success and fledgling weight (Green, 2017). The sandeel fishery off the Scottish east coast was linked to declines in breeding success of common guillemot, black-legged kittiwake and European shag (Rindorf et al., 2000), leading to a closure being introduced in 2000 which has been linked to an improved kittiwake breeding success (Greenstreet et al., 2006). A later study in the southern North Sea also correlated higher kittiwake breeding success with higher sandeel spawning stock biomass and lower sandeel fishing mortality two years previously (Carroll et al., 2017). Whilst these studies do not cover the species in this review, they indicate the potential impact of declining sandeel populations on marine bird species.

Red-throated divers may also feed on species from the cod and flatfish families (Dierschke et al., 2017; Guse et al., 2009; Natural England and JNCC, 2010; Natural England and JNCC, 2013) which may be targeted by bottom trawls. As above, the generalist feeding strategy of red-throated divers (see Section 3.8) means the impact on this species is likely low. The prey species of common scoter and little gull are unlikely to overlap with species targeted by bottom trawls (Hayman and Hume, 2001; Natural England, 2012a).

Bottom trawl fisheries may catch a range of demersal species as bycatch (Gubbay and Knapman, 1999; Seafish, 2021). For example, Nephrops trawls may catch small round fish and flat fish below the minimum conservation reference size (Seafish, 2021). It is noted that selective devices and mesh sizes are often used in bottom trawls to reduce bycatch of small or non-target fish which may reduce the potential impact on prey availability for marine birds (Seafish, 2021). However, the use and effectiveness of these methods must be considered, for example, the work done by Kennelly and Broadhurst (2021) detailing and evaluating size selectivity techniques for fish trawls.

Demersal seines

UK demersal seines mostly target cod, haddock, hake, monkfish, whiting, lemon sole, plaice and other species from the flatfish family (Seafish, 2021). Prey species of little gull, common scoter and tern species are generally not likely to be targeted by demersal seines. Despite this, tern species are recorded to also take small numbers of gadoids as secondary prey to sandeels and clupeids so a potential pathway for impact exists (Green, 2017). Whilst red-throated divers are known to feed on flatfish and cod, their generalist feeding style may lessen any impacts on prey species targeted by demersal seines (Guse et al., 2009).

Depending on what species demersal seines are targeting, bycatch may include cod, flatfish, haddock, immature round fish, juvenile target species, megrims, monkfish, plaice and other demersal species (Seafish, 2021). There is the potential for prey species of tern and red-throated diver to be caught as bycatch by demersal seines, however, the level of impact is unknown. Prey species of common scoter and little gulls are unlikely to be bycaught. Demersal seines targeting whitefish and Nephrops do not generally catch sandeels so bycatch impacts are unlikely for terns and red-throated divers preying on sandeels (JNCC, 2014).

Dredges

Prey species of red-throated divers, little gulls and tern species are unlikely to be targeted by UK dredge fisheries. However, common scoter predominantly feed on sedentary benthic bivalves such as Macoma, Mytilus and Cardium (Kaiser et al., 2002), which can be highly sensitive to selective extraction from dredging (Natural England, 2012a). Bivalve dredging has been shown to negatively impact common scoter and other benthic bivalve feeding ducks through effects on their food source and feeding grounds (Natural England, 2012a). A prohibition of boat dredging in Solway Firth was linked to an increase in common scoter numbers which was thought to be related to a recovery in cockle stocks and reduced disturbance (Hartley, 2007). Dredging for deep burrowing bivalves may also indirectly impact the surficial bivalves common scoter feed on through changing community structure and function (The Marine Institute and BIM, 2019).

It has been found that even with a fine mesh to sample sandeels, efficiency of catching sandeels with dredges is less than 12% (JNCC, 2014). However, evidence suggests that scallop dredges may cause mortality of non-target sandeels buried in sediments (Eleftheriou and Robertson, 1992). Therefore, there is a possible impact pathway for red-throated diver and tern species that feed on sandeels. Hydraulic dredge methods may pose a greater risk to benthic prey species such as sandeels due to the extent that they penetrate and disturb sediments (JNCC, 2014). Other prey species of marine birds such as sprat, herring, cod and flatfish are unlikely to be bycaught in dredge fisheries. For example, a study on Danish dredge bivalve fisheries found the fishery to have no negative impact on food availability for little terns (Nielsen et al., 2021).

4.2.2 Changes in suspended solids (water clarity)

Bottom trawls, demersal seines and dredges

Bottom towed gear may disturb sediments and result in hydrodynamic action that leads to entrainment and suspension of the substrate behind and around the gear components (Natural England and JNCC, 2021; O'Neill and Summerbell, 2011). This can lead to increased sedimentation and turbidity (Jarrett et al., 2017). Further detail on the specific pathways through which bottom towed gear types may cause changes in suspended solids for likely supporting habitats of marine bird species (sand, mud and sediments) can be found in section 8 of the Stage 3 Fishing Gear MPA Impacts Evidence Bottom Towed Gear document[3].

Impacts of changes to water clarity will depend on the species and how important water clarity is for their feeding strategies. Increased turbidity may reduce the catchability of fish by marine birds and increase the time needed for them to catch enough food (van Kruchten and van der Hammen, 2011). For breeding tern species, this may reduce the amount of food brought to chicks, which may lead to reduced breeding success (van Kruchten and van der Hammen, 2011). Conversely, increased turbidity may be caused by increased suspended organic matter such as phytoplankton which may be a food source for and attract small fish, increasing prey availability for certain marine birds (Henkel, 2006).

It is important to consider natural background turbidity levels when assessing impacts of fishing gear on turbidity (van Kruchten and van der Hammen, 2011). For example, a study in Denmark considered that the total annual release of suspended particles due to mussel dredging at the site studied was relatively unimportant compared with the total annual wind-induced resuspension (Riemann and Hoffmann, 1991).

Red-throated divers rely on underwater vision and clear water to catch prey (Natural England and JNCC, 2021). Any reductions in water clarity caused by fishing activity may therefore impact red-throated diver foraging abilities.

Impacts of water clarity on terns is variable between species and different studies. Haney and Stone (1988) presented findings that plunge-diving was more common in turbid waters for common terns and Sandwich terns off the coast of the south-eastern United States and Holbech et al. (2018) concluded that water clarity did not constrain prey capture success of common terns in coastal Ghana. Conversely, Baptist and Leopold (2010) found that capture success (percentage successful dives) of Sandwich terns was significantly higher at greater water transparencies and individuals varied their diving technique depending on water clarity, dominantly using full plunge dives in clear water and partial plunge dives and contact dips more frequently in turbid water. Similarly, food intake rates of little and Sandwich terns were found to be lower in more turbid waters off the coast of West Africa (Brenninkmeijer et al., 2002). Visual predators such as herring and sprat are recorded to avoid turbid waters in Dutch coastal waters (Essink, 1999), suggesting that any reduction in tern prey intake may be due to a reduction in available prey rather than reduced ability to forage.

Changes in suspended solids from bottom towed gear are unlikely to impact the foraging ability of little gulls due to their surface dipping feeding strategy (Hayman and Hume, 2001). Whilst common scoter dive deep in search of food (Hayman and Hume, 2001), it is unlikely that they are visual feeders and it is thought that diving ducks generally feed by touch (Kaiser et al., 2002). Therefore, an increase in turbidity caused by the movement of bottom towed gears is unlikely to impact this species.

4.2.3 Physical loss, change or damage to supporting habitat

Bottom trawls, demersal seines and dredges

Bottom towed gears may cause physical loss, change or damage to supporting habitats through abrasion, disturbance and penetration of seabed and subsurface substrates, in addition to smothering and siltation rate changes (Natural England and JNCC, 2021).

Supporting habitats for marine bird species covered in this review (described in section 3) which may be impacted by bottom towed gear pressures are sand, mud and mixed sediments. Section 3.8 includes information about supporting habitats requiring consideration based on those that are spawning and nursery areas for relevant marine bird prey items. Impacts to herring and sandeel spawning grounds and sandeel nursery grounds may have implications for red-throated diver, Sandwich tern, little tern and common tern which feed on them.

The generalist feeding strategy of red-throated divers (see Section 3.8) means impacts to herring and sandeel spawning and nursery grounds is likely low risk. However, impacts on tern species may be greater given their sensitivity to prey availability (see Section 3.8).

The specific pathways through which bottom towed gear types may cause physical loss, change or damage to supporting habitats are discussed in section 8 of the Stage 3 Fishing Gear MPA Impacts Evidence Bottom Towed Gear document[3]. Evidence indicates that there is a potential pathway for bottom towed gear to disturb sand, mud and mixed sediment habitats via abrasion and penetration pressures.

Impacts from bottom towed gear on supporting habitat may occur on a scale that could have a significant impact on marine bird species. Site level assessments are needed to fully consider the impacts of these pressures.

MMO is assessing seabed habitats of other offshore MPAs through Stage 2 and Stage 3 of this work (described online). Where management is identified as required, and the relevant MPAs overlap with the marine bird MPAs in consideration, this may contribute to the protection of supporting habitat for marine birds in certain areas.

4.3 Summary of the effects of bottom towed gear on marine birds

Bottom towed gears have the potential to impact the marine bird species covered in this review. As such, site level assessments are required to determine whether management may be needed for MPAs protecting these features. Table 2 summarises the potential pressures caused by bottom towed gear alongside the marine bird species which the evidence indicates to be of most concern for each pressure. This does not rule out further species which may require site level assessment regarding these pressures, which are also listed in the table.

Additionally, the presence of fishing vessels irrespective of gears used, exert pressures that need to be considered in site level assessments, but are covered in the fishing vessel presence section.

Table 2. Summary of potential pressures caused by bottom towed gear.

Potential pressure	Species of concern indicated by the evidence	Other species which may require site level assessment
Marine bird bycatch		Common tern, little tern, Sandwich tern, red-throated diver, common scoter, little gull
Removal of target and non-target prey species	Common tern, Sandwich tern, little tern, common scoter	Red-throated diver, little gull
Changes in water clarity	Common tern, little tern, Sandwich tern, red-throated diver	Little gull, common scoter
Physical loss, change or damage to supporting habitats	Common tern, little tern, Sandwich tern	Red-throated diver, common scoter, little gull

5 Midwater gear

This section brings together and analyses the available evidence on how midwater gear affects marine birds. As a result of midwater gear, marine birds may be sensitive to the following pressures, which are considered in this document:

Direct impacts

- marine bird bycatch (removal of non-target species);

Indirect impacts

- removal of target and non-target prey species.

5.1 Direct impacts

5.1.1 Marine bird bycatch

Midwater towed gear

Midwater trawls operate in closer proximity to the surface than bottom towed gears which may encourage diving birds, such as alcids and cormorants, to dive in order to capture fish in the net, leading to higher bycatch rates (Northridge et al., 2020). This also means that midwater trawls are more likely to operate within the foraging range of the marine bird species covered in this review.

Sampling efforts for the UK Bycatch Monitoring Programme for 1996 to 2018, observed 2,239 midwater trawl hauls (generally targeting bass and sprat) and reported bycatch of 32 marine birds, 85% of which were guillemots and the others, cormorants and razorbills (Northridge et al., 2020). This study did not record the species relevant to this review as bycatch of midwater trawls. Studies between 1998 and 2011 observed very little marine bird mortality from midwater trawl fisheries off the east coast of Canada, with shearwaters being the main species bycaught (Hedd et al., 2016). A study in the Atlantic from 1998 to 2008 observed no marine birds as bycatch of midwater trawls (Ellis et al., 2013), however, this information is treated with caution as the number of trawls observed and proportion of likely trawls is not provided. Between 2015 and 2016, Sigourney et al. (2019) recorded marine bird bycatch from four types of commercial fishing gear in the northeast and mid-Atlantic, with a total of 655 birds bycaught from all gears. Five birds were bycaught in midwater trawls during 0.3 days observed fishing effort (Sigourney et al., 2019). Other gear types observed included gillnets, sea scallop dredges and bottom trawls (Sigourney et al., 2019). In the Baltic Sea where midwater otter trawls are a major fishery, no marine bird bycatch was reported to occur, whereas in a small study in the North Sea, bycaught Northern gannet were recorded (ICES, 2013).

Through considering the increased sensitivity of species diving at depths overlapping with fishing gear, time spent at these depths and direct evidence of species being caught, Bradbury et al. (2017) calculated the pelagic entrapment risk for red-throated diver to be 4 out of 5 (4 = typically benthic feeders which occasionally forage on pelagic prey, limited evidence of bycatch and 5 = species which solely rely on pelagic prey and are active throughout the water column, relevant evidence of bycatch) (Bradbury et al., 2017). Common scoter was also scored 4, Sandwich tern, little tern and common tern were scored 2 and little gull was scored 1 (1 = species that feed at the surface without diving, no relevant evidence of bycatch and 2 = surface/sub-surface feeders that may submerge but are not pursuit feeders, no relevant evidence of bycatch) (Bradbury et al., 2017). The attraction of marine bird species to midwater trawls must be considered in addition to entrapment risk. For example, the tendency of red-throated divers to fly away from fishing vessels means they are less likely to be bycaught in comparison to species that actively pursue vessels in search of food (ICES, 2018). Similarly, the strong escape behaviour for common scoter in relation to vessel traffic (Bradbury et al., 2014) is likely to reduce their bycatch risk. Despite attendance of marine birds such as gulls and terns at midwater trawls off northern and central Patagonia, trawling was not found to be an important source of marine bird mortality (Pon et al., 2013).

Purse seines

Marine birds may be attracted to purse-seines as they usually target small pelagic fish such as sardine and chub mackerel, which are key prey species of marine birds (Wise et al., 2019). Purse seines may facilitate foraging opportunities for marine birds, for example through the process of slipping where part of the catch is released over the floating line, or through feeding within the nets themselves (Stratoudakis and Marçalo, 2002). Marine birds may be bycaught by purse seines, with a three-year study in Portuguese waters reporting a bycatch rate of 0.04 birds/trip consisting mostly of surface-feeding and scavenging gulls (Calado et al., 2021). This suggests that the surface feeding tern and gull species covered in this review may be at risk from bycatch in relation to purse seines. Despite this, there is generally limited evidence of marine birds being recorded as bycatch in purse seine gear (Gilman, 2011; Baker and Hamilton, 2016). Additionally, mitigation techniques such as fishing at night and close attendance of purse seine gear have been found to reduce marine bird interaction levels with purse seines (Baker and Hamilton, 2016).

5.2 Indirect impacts

5.2.1 Removal of target and non-target prey species

Midwater gear may cause the removal, harm or mortality of prey species of marine birds. Prey species may be target species of fisheries, non-target bycatch or harmed but not removed by fishing operations. This may cause a direct or indirect reduction in food availability for overwintering marine birds (Natural England, 2012a; Jarrett et al., 2017).

Midwater towed gear and purse seines

Midwater trawls predominantly target blue whiting, anchovies, herring, mackerel and scad in the UK, with reports of sprat also being a target species (Seafish, 2021). Purse seines mostly target anchovies, herring, mackerel, sardines, scad and yellow fin tuna (Seafish, 2021). Midwater trawls and purse seines may also catch juvenile target species as bycatch, with pelagic pair trawls potentially catching higher swimming fish as bycatch (Seafish, 2021). Prey species of common scoter and little gull (see section 3) are therefore unlikely to be impacted by midwater trawls or purse seines. Midwater trawls and purse seines may reduce prey for red-throated divers, common tern and little tern, which are known to feed on herring, and Sandwich terns which are reported to feed on whiting (British Trust for Ornithology, 2021; Eglington and Perrow, 2014; Guse et al., 2009; Natural England and JNCC, 2010; Natural England and JNCC, 2013; RSPB, 2021). The generalist feeding strategy of red-throated divers means the impact on this species from midwater trawls is likely minimal, however tern species may be more susceptible due to their sensitivity to prey availability (see Section 3.1). Furthermore, herring abundance has been closely linked to common tern breeding success due to terns feeding on herring that have been spawned in the autumn or winter before their breeding season (Dänhardt and Becker, 2011).

Removal of predatory fish through fisheries may reduce feeding opportunities for marine bird species which feed on concentrated bait balls driven to the surface by predatory fish. For example, schooling mackerel compact targeted sandeel (Tasker et al., 2000; Robinson and Tetley, 2007). The removal of mackerel by midwater trawls and purse seines may therefore impact the feeding ability of tern species.

5.3 Summary of the effects of midwater gear on marine birds

Midwater gears have the potential to impact the marine bird species covered in this review. As such, site level assessments are required to determine whether management may be needed for MPAs protecting these features. Table 3 summarises the potential pressures caused by midwater gear alongside the marine bird species which the evidence indicates to be of most concern for each pressure. This does not rule out further species which may require site level assessment regarding these pressures, which are also listed in the table.

Additionally, the presence of fishing vessels irrespective of gears used, exert pressures that need to be considered in site level assessments too, but are covered in the fishing vessel presence section.

Table 3. Summary of potential pressures caused by midwater gear.

Potential pressure	Species of concern indicated by the evidence	Other species which may require site level assessment
Marine bird bycatch		Common tern, little tern, Sandwich tern, red-throated diver, common scoter, little gull
Removal of target and non-target prey species	Common tern, Sandwich tern, little tern	Red-throated diver, little gull, common scoter

6 Anchored nets and lines

This section brings together and analyses the available evidence on how anchored nets and lines affect marine birds. As a result of anchored nets and lines, marine birds may be sensitive to the following pressures, which are considered in this document:

Direct impacts

- marine bird bycatch (removal of non-target species);

Indirect impacts

- removal of target and non-target prey species;
- physical loss, change or damage to supporting habitat.

6.1 Direct impacts

6.1.1 Marine bird bycatch

Gillnets

Monofilament gillnets create the risk of birds being caught as bycatch because the nets are almost invisible underwater (Furness, 2003). Lost and discarded nets can also cause marine bird bycatch mortality (Furness, 2003). Bird species that are most susceptible to bycatch in gillnet fisheries are those that forage by diving for fish or benthic fauna (Sonntag et al., 2012, Žydelis et al., 2013).

Žydelis et al. (2013) classified that red-throated diver are susceptible to entanglement in gillnets due to foraging behaviour, with the species recorded to have been caught in nets. A study modelling the bycatch of common divers and red-throated divers in gillnets along the US Atlantic coast estimated an average annual bycatch of 551 great northern divers (*Gavia immer)* and 897 red-throated divers

(Warden, 2010). This study estimated that average red-throated diver bycatch was around 60% PBR (Potential Biological Removal, a threshold of additional annual mortality which could be sustained by the population, Žydelis et al., 2009). Žydelis et al. (2009) reviewed studies reporting gillnet bycatch of marine bird species in coastal gillnet fisheries of the North Sea and Baltic Sea, reporting that red-throated diver and black-throated diver (*Gavia arctica)* bycatch in gillnets was in the order of hundreds of birds annually.

Žydelis et al. (2013) also classified common scoter as susceptible to entanglement in gillnets due to foraging behaviour. Žydelis et al. (2013) noted specific bycatch incidents, for instance 340 common and velvet scoter (Melanitta fusca) drowned in one night in one area of Danish Waters in the North Sea (Durinck et al., 1993). Žydelis et al. (2009) reported that for common scoter, bycatch was in the order of thousands in the North Sea and Baltic Sea (Žydelis et al., 2009). Oliveira et al. (2015) recorded set nets to have an average bycatch of 0.06 marine birds per set and had the greatest marine bird species diversity bycatch with seven species recorded, including common scoter (6% of observed bycatch).

Žydelis et al. (2013) classified the little gull, sandwich tern, little tern and common tern as not susceptible to bycatch in gillnets (Žydelis et al., 2013).

Between 2015 and 2016, Sigourney et al. (2019) recorded marine bird bycatch from four types of commercial fishing gear in the northeast and mid-Atlantic. A total of 655 birds bycaught from all gears, whilst 613 birds were bycaught in gillnets during 4,493 days of observed fishing effort (Sigourney et al., 2019). Great Shearwaters dominated bycatch in the northeast Atlantic, mostly in gillnets, whereas common loons and red-throated loons (red-throated divers) were bycaught the most in the mid-Atlantic, also most likely in gillnets (Sigourney et al., 2019).

Northridge et al. (2020) estimated bycatch of marine birds by UK vessels in static gillnet fisheries around the UK from 1996 to 2018, based on over 21,000 observed fishing operations. This study provides no bycatch records of the marine bird species this review focuses on.

Žydelis et al. (2013) reviewed studies of marine bird bycatch in gillnet fisheries worldwide. They gathered information from observers, fishermen, questionnaires, ring recoveries, stranded bird surveys and opportunistic observations. Žydelis et al. (2013) estimate that 400,000 marine birds die annually worldwide as a result of gillnet bycatch. To obtain this figure, Žydelis et al. (2013) used models, extrapolations and best guesses with differing metrics and methods for collecting the data between studies resulting in varying levels of uncertainty.

Sonntag et al. (2012) assessed the spatial overlap and conflict between marine bird populations and gillnet fisheries in the southern Baltic Sea and found strong evidence for the conflict between gillnet fisheries and conservation objectives for marine birds in the study area where marine birds and gillnet fisheries overlap spatially and temporally. Regional populations of marine birds have seen declines resulting from high mortality rates caused by gillnet bycatch (Piatt et al., 1984).

Longline

Marine birds scavenging near longline fisheries are susceptible to bycatch mainly during two phases of the fishing operation, when the baited hooks are accessible to marine birds at the line setting or line hauling phase (Brothers et al., 2010).

There are two distinct longline fisheries in the UK: large vessels fishing offshore in the northern North Sea and western waters targeting hake, and coastal under 10 m vessels operating in the English Channel and North Sea targeting various species, which include cod and ray (Northridge et al., 2020). The study by Northridge et al. (2020) provided no bycatch records of the marine bird species this review focuses on.

There is little evidence concerning the impacts of longline marine bird bycatch in the UK. Interpretation of studies relating to other species and regions is done with caution, as many factors will affect bycatch, including differences in marine bird species behaviour, fishing gear configurations and many others.

Anderson et al. (2011) reviewed published and unpublished literature on marine bird bycatch in longline fisheries worldwide with available data to estimate annual marine bird mortality of between 160,000 and 320,000 (average and upper range of estimates), which the authors consider very likely to be an underestimate. Anderson et al. (2011) point out that in many cases assumptions, estimations and extrapolations were necessary to extract data from literature, and that there was poor data reliability for most of the top fleets used in this study.

Oliveira et al. (2015) observed marine bird bycatch onboard vessels operating in Portuguese waters using different gears. They found that under 12 m vessels using demersal longlines had the highest proportion of trips with bycatch, with an average of 0.24 birds per 1000 hooks, consisting exclusively of Nothern gannets.

Cortés et al. (2017) studied the interaction between marine birds and demersal longlines in the Balearic Islands. They found an average bycatch rate of 0.58 birds per 1000 hooks, estimating that 274 to 2198 marine birds were caught annually in the study area. The species covered in this review are not listed in the most commonly caught species in this study, which include species of shearwater (Cortés et al., 2017).

In a study observing marine bird bycatch and mortality in a longline fishery in the Mediterranean around Columbretes Islands, the authors found the average bycatch rate of 0.16 - 0.69 birds per 1000 hooks, with an estimate of 656 to 2829 birds killed annually in the study area (Belda and Sánchez, 2001). As above, the species bycaught do not include those covered by this review, with the Cory’s shearwater (*Calonectris diomedea*) being the most commonly bycaught species (Belda and Sánchez, 2001).

6.2 Indirect impacts

6.2.1 Removal of target and non-target prey species

Anchored nets and lines may cause the removal, harm or mortality of marine bird prey species. Prey may be target species of fisheries, non-target bycatch or harmed but not removed by fishing operations. This may cause a direct or indirect reduction in food availability for overwintering and breeding marine birds (Natural England, 2012a; Jarrett et al., 2017).

According to Seafish (2023i), the main species targeted by the following UK fisheries are:

- Gillnets: monkfish, dogfish, hake, pollock, skates, megrim, haddock, cod.
- Tangle nets: brill, Dover sole, monkfish, plaice, skates, spider crabs and turbot.
- Trammel nets: brill, cod, Dover sole, flats, monkfish, pollack, haddock and hake.
- Longlines: any demersal species, bass, cod, dogfish, haddock, halibut, ling, pollack, saithe, skates, tuna and turbot.

The above fisheries may also remove any demersal species as bycatch (Seafish, 2023i).

The difference in target species of anchored nets and lines and typical prey of little gulls and common scoter (see section 3) suggests these marine bird species are unlikely to be negatively impacted by removal of target species from UK anchored net and line fisheries.

Red-throated divers are known to feed on species from cod and flatfish families which may also be targeted by anchored nets and lines (Dierschke et al., 2017; Guse et al., 2009; Natural England and JNCC, 2010; Natural England and JNCC, 2013). However, the generalist feeding strategy of red-throated divers (see Section 3.1) means the impact on this species is likely low.

Gadoids, such as cod and saithe, may be preyed upon by Sandwich and common terns so a potential pathway for impact from anchored nets and lines exists. However, gadoids are often taken as secondary prey to sandeels and clupeids (Green, 2017), suggesting that impacts may only occur where sandeels and clupeids are not available.

6.2.2 Physical loss, change or damage to supporting habitat

Anchored nets and lines may cause physical loss, change or damage to supporting habitats through abrasion, disturbance and penetration of seabed and subsurface substrates (Natural England and JNCC, 2021).

Supporting habitats for marine bird species covered in this review (described in section 3) which may be impacted by bottom towed gear pressures are sand, mud and mixed sediments. Section 3.8 includes information about supporting habitats requiring consideration based on those that are spawning and nursery areas for relevant marine bird prey items. Impacts to herring and sandeel spawning grounds and sandeel nursery grounds may have implications for red-throated diver, Sandwich tern, little tern and common tern which feed on them.

The generalist feeding strategy of red-throated divers (see Section 3.8) means impacts to herring and sandeel spawning and nursery grounds is likely low risk. However, impacts on tern species may be greater given their sensitivity to prey availability (see Section 3.8).

The specific pathways through which anchored nets and lines may cause physical loss, change or damage to supporting habitats are discussed in section 9 of the Stage 3 Fishing Gear MPA Impacts Evidence Anchored Nets and Lines document[33]. Evidence indicates there is a potential pathway for anchored nets and lines to disturb sand, mud and mixed sediment habitats via abrasion and penetration pressures. Whilst this impact is unlikely to occur on a scale that will have a significant impact on marine bird species, site level assessments are needed to fully consider the impacts of these pressures.

MMO is assessing seabed habitats of other offshore MPAs through Stage 2 and Stage 3 of this work (described online). Where management is identified as required, and the relevant MPAs overlap with the marine bird MPAs in consideration, this may contribute to the protection of supporting habitat for marine birds in certain areas.

6.3 Summary of the effects of anchored nets and lines on marine birds

Anchored nets and lines have the potential to impact the marine bird species covered in this review. As such, site level assessments are required to determine whether management may be needed for MPAs protecting these features. Table 4 summarises the potential pressures caused by anchored nets and lines alongside the marine bird species which the evidence indicates to be of most concern for each pressure. This does not rule out further species which may require site level assessment regarding these pressures, which are also listed in the table.

Additionally, the presence of fishing vessels irrespective of gears used, exert pressures that need to be considered in site level assessments too, but are covered in the fishing vessel presence section.

Table 4. Summary of potential pressures caused by anchored nets and lines.

Potential pressure	Species of concern indicated by the evidence	Other species which may require site level assessment
Marine bird bycatch	Red-throated diver, common scoter	Common tern, little tern, Sandwich tern, little gull
Removal of target and non-target prey species		Common tern, Sandwich tern, little tern, common scoter, red-throated diver, little gull
Physical loss, change or damage to supporting habitats		Common tern, little tern, Sandwich tern, red-throated diver, common scoter, little gull

7 Traps

This section brings together and analyses the available evidence on how traps affect marine birds. As a result of traps, marine birds may be sensitive to the following pressures, which are considered in this document:

Direct impacts

- marine bird bycatch (removal of non-target species);

Indirect impacts

- removal of target and non-target prey species;
- physical loss, change or damage to supporting habitat.

7.1 Direct impacts

7.1.1 Marine bird bycatch

There is the potential for active traps to create a bycatch risk for marine birds, however, the taking of marine birds by potting gear has been found to be relatively rare in comparison to other gears such as hook and lines (Jarrett et al., 2017; Krieger and Eich, 2021). A study by the Department of Fisheries and Oceans Fisheries Observer Program in the Atlantic from 1998 to 2008 observed no marine bird species as bycatch of traps and pots (Ellis et al., 2013). On-board observations of Portuguese mainland fisheries in two different studies recorded no captured marine birds from traps in 95 trips (Calado et al., 2021) and 14 trips respectively (Oliveira et al., 2015). Since traps generally have a lower catch rate in comparison to other fishing methods such as purse seining, this makes them less attractive to surface feeding marine birds such a gulls, possibly explaining the low marine bird bycatch rates (Calado et al., 2021). Studies have reported bycatch of cormorants from lobster traps in Baja California (Shester and Micheli, 2011) and European shag from pots and traps in the North-eastern Atlantic (ICES, 2013). It is noted that cormorants and European shags tend to dive deeper than the species covered in this review (Quintana et al., 2007; Daunt et al., 2015), which may mean they are more likely to interact with traps set on the seafloor.

There is limited information on bycatch risk from traps towards red-throated diver, common scoter, tern species and little gull. Diving species may enter a pot whilst foraging (Krieger and Eich, 2021). Red-throated divers have been reported to have a maximum diving depth of less than 20 m, most frequently diving to depths of 2 to 6 m (Duckworth et al., 2020). The reported maximum dive depth for common scoter is 20 m (Kaiser et al., 2006). This indicates that in some cases these species may dive deep enough to interact with traps set on the seafloor, however, there is little evidence suggesting that bycatch in traps occurs frequently. Reports of mortality of surface feeding marine birds due to potting are low, for example a study of pot fisheries on the west coast of the United States reported no bycaught Northern fulmars from 2012 to 2018, no bycaught gulls from 2012 to 2017, and one bycaught gull in 2018 (Jannot et al., 2021). The shallow feeding strategies of little gulls, common terns and Sandwich terns means that they are unlikely to be caught in traps whilst diving. Surface and near-surface foragers may instead be “captured” in pots on deck before they are deployed or may collide with pots on deck during bad weather (Krieger and Eich, 2021).

7.2 Indirect impacts

7.2.1 Removal of target and non-target prey species

Traps may cause the removal, harm or mortality of prey species of marine birds. Prey may be target species of fisheries, non-target bycatch or harmed but not removed by fishing operations. This may cause a direct or indirect reduction in food availability for overwintering marine birds (Natural England, 2012a; Jarrett et al., 2017).

UK trap fisheries generally target crabs, lobsters, cuttlefish, Nephrops, prawns and whelk. The difference in target species of traps and typical prey of the relevant marine birds (see section 3) suggests these marine bird species are unlikely to be negatively impacted by removal of target species from UK trap fisheries.

Bycatch from whelk pots is negligible due to the design of the pots, as most other fish and shellfish can escape easily before the gear is hauled and any unwanted bycatch can be returned to the sea alive (Seafish, 2021). Bycatch from lobster and crab potting is minimal and usually confined to undersized crabs and lobsters and various non target crab species (Seafish, 2021). Similarly, bycatch in prawn creels is minimal and usually consists of small individuals of the target species and a few small fish (Seafish, 2021). Bycatch can be minimised by the use of appropriate mesh sizes in the cover netting and the use of relevant escape gaps (Seafish, 2021). Any bycatch in the pots can be easily removed from the pot and released back into the sea immediately without harm (Seafish, 2021). This suggests that potting may not have a significant impact on prey availability for marine birds through removal of non-target species.

7.2.2 Physical loss, change or damage to supporting habitat

Traps may cause physical loss, change or damage to supporting habitats through abrasion and disturbance of seabed surface substrates (Natural England and JNCC, 2021).

Supporting habitats for marine bird species covered in this review (described in section 3) that may be impacted by bottom towed gear pressures are sand, mud and mixed sediments. Section 3.8 includes information about supporting habitats requiring consideration based on those that are spawning and nursery areas for relevant marine bird prey items. Impacts to herring and sandeel spawning grounds and sandeel nursery grounds may have implications for red-throated diver, Sandwich tern, little tern and common tern which feed on them.

The generalist feeding strategy of red-throated divers (see Section 3.8) means impacts to herring and sandeel spawning and nursery grounds is likely low risk. However, impacts on tern species may be greater given their sensitivity to prey availability (see Section 3.8).

The specific pathways through which traps may cause physical loss, change or damage to supporting habitats are discussed in section 9 of the Stage 3 Fishing Gear MPA Impacts Evidence Traps document[33]. Evidence indicates there is a potential pathway for traps to disturb sand, mud and mixed sediment habitats via abrasion. Whilst this impact is unlikely to occur on a scale that will have a significant impact on marine bird species, site level assessments are needed to fully consider the impacts of these pressures.

MMO is assessing seabed habitats of other offshore MPAs through Stage 2 and Stage 3 of this work (described online). Where management is identified as required, and the relevant MPAs overlap with the marine bird MPAs in consideration, this may contribute to the protection of supporting habitat for marine birds in certain areas.

7.3 Summary of the effects of traps on marine birds

The risk posed to the marine bird species covered in this review from traps is low, however, a pathway for disturbance does exist. As such, site level assessments are required to determine whether management may be needed for MPAs protecting these features. Table 5 summarises the potential pressures caused by traps alongside the marine bird species which the evidence indicates to be of most concern for each pressure. This does not rule out further species which may require site level assessment regarding these pressures, which are also listed in the table.

Additionally, the presence of fishing vessels irrespective of gears used, exert pressures that need to be considered in site level assessments too, but are covered in the fishing vessel presence section.

Table 5. Summary of potential pressures caused by traps.

Potential pressure	Species of concern indicated by the evidence	Other species which may require site level assessment
Marine bird bycatch		Common tern, little tern, Sandwich tern, red-throated diver, common scoter, little gull
Removal of target and non-target prey species		Common tern, Sandwich tern, little tern, common scoter, red-throated diver, little gull
Physical loss, change or damage to supporting habitats		Common tern, little tern, Sandwich tern, red-throated diver, common scoter, little gull

8 Fishing vessel presence

This section brings together and analyses the available evidence on how fishing vessel presence affects marine birds. As a result of fishing vessel presence, marine birds may be sensitive to the following pressures, which are considered in this document:

Direct impacts

- non-physical disturbance;
- collision ABOVE/BELOW water with static or moving objects not naturally found in the marine environment.

8.1 Direct impacts

8.1.1 Non-physical disturbance

Non-physical disturbance includes both visual and noise disturbance. The operation of gear and vessels, as well as presence of people, may result in an increase in above water noise (Natural England and JNCC, 2021; Seafish, 1988). Underwater noise is mostly produced through propeller cavitation, but the deployment, towing and hauling of gear as well as turbulence around the hull and the use of fish finding sonars will also be a source (Natural England and JNCC, 2021; OSPAR Commission, 2009). Noise produced varies with vessel size, with larger vessels generating lower frequency sound (Natural England and JNCC, 2021). The movement of vessels and people, as well as fishing gear, can create visual stimuli which may trigger varying disturbance responses in marine birds, depending on the size, profile and distance of the vessel (Marcella et al., 2017; Natural England and JNCC, 2021; Ronconi and Clair, 2002). Noise and visual disturbance may reduce or stop marine birds feeding in an area or tracking areas of high food abundance, and potentially cause displacement to another less favoured area to feed; either response could decrease the energy intake and therefore the survival of marine birds (Natural England, 2012a). A shift in populations to suboptimal habitats may cause poorer health prior to breeding, in turn reducing reproductive success and increasing mortality in adult individuals (Mendel et al., 2019). Non-physical disturbance may have more serious impacts on diving birds due to their energetically expensive foraging method (Natural England, 2012a; Ronconi and Clair, 2002).

Red-throated divers are highly sensitive to vessel disturbance at sea and have shown clear avoidance of areas with high shipping intensity, with studies finding higher abundance in areas with low-frequency ship traffic (Garthe and Hüppop, 2004; Schwemmer et al., 2011; Furness et al., 2013; Burger et al., 2019). Escape distances describe the linear distance from a vessel to a bird at the point of flight from the water (Schwemmer et al., 2011). Multiple studies have recorded escape distances in response to research vessels and ships; one study recorded a median escape distance of 400 m with maximum distances recorded of over 1,000 m (Bellebaum et al., 2006), whilst another study recorded a mean escape distance of 750 m for individual red-throated divers (maximum 1,700 m) and a mean of 702 m for a flock (Fliessbach et al., 2019). A modelling study focused on Liverpool Bay MPA found 2 km to be an important distance in relation to ship disturbance, with average predicted numbers of red-throated divers increasing from 0 to 2 km from the nearest ship (Burt et al., 2017). Numerous studies have calculated high disturbance indices for red-throated divers. For example, red-throated divers scored 5 out of 5 for disturbance susceptibility in relation to offshore windfarms and associated traffic (Bradbury et al., 2014). Fliessbach et al. (2019) calculated the displacement vulnerability index (DVI) in relation to ship disturbance for 26 bird species, which was defined by the probability of a disturbance event based on species' shyness, the energetic costs of escape for each disturbance event and the population-level costs based on status factors. Each component was scored 1-5 and multiplied together to calculate the DVI, therefore giving a maximum score of 125 (Fliessbach et al., 2019). Red-throated divers were calculated to have a very high displacement index in response to marine traffic and transport and calculated to have the highest DVI (77.8) out of the 26 species regarding ship disturbance (Fliessbach et al., 2019). Red-throated divers therefore have a strong escape behaviour at a large response distance (Bradbury et al., 2014; Mendel et al., 2019). Disturbance responses have been found to be strongest within a five kilometre radius and within 5 minutes of the passing of a vessel, with high speed vessels (over 40 km/hour) thought to have an increased impact (Burger et al., 2019). It is thought wintering areas of red-throated divers can be displaced by a radius of more than 15 km as a result of windfarms and associated vessels, whilst impacts of fishing vessels are likely to be less pronounced compared to windfarms, regularly fished areas may result in displacement of individuals (Mendel et al., 2019). Therefore, this suggests that red-throated divers are susceptible to non-physical disturbance.

Common scoter are known to be one of the most sensitive species to disturbance from the presence of vessels and this may result in displacement of individuals (The Marine Institute and BIM, 2019; Furness et al., 2013; Garthe and Hüppop, 2004). Disturbance susceptibility indices for common scoter are calculated to be high compared to other species. Common scoter scored 5 out of 5 disturbance susceptibility in relation to offshore windfarms and associated marine traffic (Bradbury et al., 2014). Common scoter were calculated to have a relatively high DVI compared to other species in relation to ship disturbance (43.3) (Fliessbach et al., 2019) and displacement indices in relation to marine traffic and transport were calculated as very high (Garthe and Hüppop, 2004; MMO, 2018; Schwemmer et al., 2011). Common scoter therefore have a strong escape behaviour, at a large response distance (Bradbury et al., 2014). Escape distances for common scoter have been found to be larger than those for many marine bird species, with one study recording a mean of 1,600 m for individuals (maximum 3,200 m) and a mean of 1015 m for a flock (Fliessbach et al., 2019), another study reporting a median of 804 m (Schwemmer et al., 2011) and a further study recording large flocks to take flight at 2,000 m with smaller flocks taking flight at 1,000 m (Kaiser et al., 2002). Common scoter are thought be more likely to take flight than other species because of their low wing loading and therefore lower energy costs of taking flight (Larsen and Laubek, 2005). Common scoter are observed to not quickly return once disturbed from an area (Fliessbach et al., 2019), with one study finding most individuals did not return within three hours (Schwemmer et al., 2011). Predictive modelling in Liverpool Bay MPA also found common scoter to be more negatively impacted by larger ships with regards to estimated numbers of birds (Burt et al., 2017). Examples of common scoter disturbance from fisheries have been reported in the North Sea in response to a bivalve fishery (Tasker et al., 2000) as well as from a razor clam fishery off the coast of Dublin (The Marine Institute and BIM, 2019). Vessel disturbance may cause acute stress, for example, elevated plasma corticosterone levels in white-winged scoter have been shown to persist for 15 minutes or more after the disturbance (Palm et al., 2013). Elevated stress hormones are known to lead to body-mass changes in velvet scoter which may impact the fitness of individuals (Hennin et al., 2016).

Common terns, Sandwich terns and little terns have been reported to have a low sensitivity to disturbance by shipping activities associated with marine aggregate dredging (Cook and Burton, 2010). Tern species are generally surface feeders and highly manoeuvrable in flight and therefore are reported to show low sensitivity to disturbance caused by ship and helicopter traffic at sea (Garthe and Hüppop, 2004; Natural England and JNCC, 2021). Disturbance susceptibility indices for tern species are generally low compared to other species. Tern species scored 2 out of 5 disturbance susceptibility in relation to offshore windfarms and associated marine traffic (Bradbury et al., 2014). Sandwich terns are assessed to be sensitive to above water noise and visual disturbance but are assessed to not be sensitive to underwater noise changes (Table A1. 6). The DVI for common terns and Sandwich terns was much lower than other species (3.3 and 6.7 respectively) (Fliessbach et al., 2019) and displacement indices in relation to marine traffic and transport were calculated as moderate for little and Sandwich terns and low for common terns (Garthe and Hüppop, 2004; MMO, 2018). Terns are likely to have reduced escape behaviour and shorter flight distances when approached compared to other species (Bradbury et al., 2014). Terns are described to have a perceived lower predation risk (Fliessbach et al., 2019) which may explain their lower sensitivity to vessel disturbance.

Little gulls are assessed to be sensitive to above water noise, but there is insufficient evidence regarding underwater noise impacts, and they are assessed as not sensitive to visual disturbance (Table A1. 6). Little gulls are calculated to have a very low displacement index in response to marine traffic and transport (MMO, 2018). Garthe and Scherp (2003) documented that little gulls were rare ship followers during a study in the Baltic Sea. Little gulls were reported to have a disturbance susceptibility of 1 out of 5 to offshore windfarms and associated marine traffic (Bradbury et al., 2014), meaning that they have limited escape behaviour and a very short flight distance when approached (Garthe and Hüppop, 2004). Fliessbach et al. (2019) calculated little gull to have a lower DVI related to ship disturbance compared to other species, at 12.0.This evidence suggests that vessel presence may not cause significant negative impacts to little gulls.

8.1.2 Collision ABOVE/BELOW water with static or moving objects not naturally found in the marine environment

All vessels, including fishing vessels, have the potential to result in collision with marine bird species (vessel strikes), both above and below the water. There is limited data on marine bird strikes with fishing vessels, with most evidence relating to interactions with the fishing gear, which is covered in the marine bird bycatch sections.

Above water, marine birds may be attracted to or become disorientated by light emitted from fishing vessels and result in collision (Natural England and JNCC, 2021). Greater risk of vessel collisions occurs for ships with lighting in coastal areas close to large breeding aggregations of marine birds, rather than further offshore (Natural England and JNCC, 2021). Nocturnal bird strikes on vessels tend to occur when bright, artificial light sources are used at times of poor visibility, typically during bad weather, often angled outwards or upwards from the vessel (Natural England and JNCC, 2021). Underwater, marine bird species may collide with the propellor or other parts of the hull, with more serious injuries being cause by larger ships travelling at faster speeds (Natural England and JNCC, 2021).

Limiting the discharging of fish waste overboard and instead retaining it is suggested as a method to reduce attendance of birds at fishing vessels and the risk of collision/bycatch (Anderson et al., 2020). Various gear modifications such as bird-scaring lines may also reduce the risk of collision/bycatch (Anderson et al., 2020).

8.2 Summary of the effects of fishing vessel presence on marine birds

The pressures caused by fishing vessel presence have the potential to impact the marine bird species covered in this review. As such, site level assessments are required to determine whether management may be needed for MPAs designated for these features. Table 6 summarises the potential pressures caused by fishing vessel presence alongside the marine bird species which the evidence indicates to be of most concern for each pressure. This does not rule out further species which may require site level assessment regarding these pressures, which are also listed in the table.

Table 6. Summary of potential pressures caused by fishing vessel presence.

Potential pressure	Species of concern indicated by the evidence	Other species which may require site level assessment
Non-physical disturbance (covers visual disturbance, above water noise and underwater noise changes)	Red-throated diver, common scoter	Common tern, little tern, Sandwich tern, little gull
Collision ABOVE/BELOW water with static or moving objects not naturally found in the marine environment	Common tern, little tern, Sandwich tern, red-throated diver, common scoter, little gull	

9 Level of literature, caveats and assumptions

This review is based on information sourced from peer-reviewed scientific journals and research reports. Where possible, literature has been used from studies within the UK, however, numerous studies based outside of the UK have been used due to UK studies not being available. It is assumed that the same species will exhibit similar sensitivities to the pressures discussed regardless of location, however, such information is treated with caution due to potential differences in fishing gears used globally as well as differences in environmental conditions. Where information is lacking for a certain marine bird species, evidence has been included for species that are closely related, either within the same genus or family. Again, information is treated with caution due to potential differences between species. Information regarding typical prey species caught by bottom towed gear, midwater gear, anchored nets and lines and traps has been used to summarise impacts regarding prey availability. Deviation from these typical species may therefore change the potential impact.

9.1 Knowledge gaps: bottom towed gear

It is noted that marine bird bycatch from bottom towed gear is difficult to estimate as carcasses are often lost at sea rather than being brought onboard (Ellis et al., 2013). Therefore, the bycatch risk of species discussed in this review may be higher than portrayed by the included studies. There is minimal evidence for bycatch impacts of demersal seines, however, this gear type may cause similar impacts to bottom trawls. Evidence around the impacts of fishing gear on marine birds through impacts to their supporting habitats is lacking. Whilst evidence is available for direct impacts of fishing gear to particular habitats, this is not linked to the resulting impact on marine bird populations. Studies on impacts of fishing on prey availability are also minimal and therefore assumptions have to be made with regards to species caught by gear types and resulting impacts on marine birds.

9.2 Knowledge gaps: midwater gear

There is limited information regarding marine bird bycatch in midwater trawls and purse seines which may be due to a lack of studies or lack of bycatch in these gear types. It is noted that marine bird bycatch of larger midwater trawling vessels (50-70 m length) is more difficult to observe than smaller vessels (10-30 m length) because they pump catch directly into storage tanks rather than sorting it on deck (Northridge et al., 2020). Therefore, studies may underreport the amount of bycatch from midwater gear. Studies on the impacts of fishing on prey availability are also minimal and therefore assumptions have to be made with regards to species caught by gear types and resulting impacts on marine birds.

9.3 Knowledge gaps: anchored nets and lines

Quantifying marine bird bycatch in longline and set net fisheries remains a challenge, with bycatch going unrecorded in many fisheries (Sonntag et al., 2012) and there is a lack of estimates of the number of birds entangled in fishing gear (Žydelis et al., 2009).

For many fisheries, marine bird bycatch rates are still mostly unknown, particularly in artisanal fisheries (Anderson et al., 2011, Žydelis et al., 2013). The northeast Atlantic and North Sea lacks data and studies estimating bycatch of birds, and there are no systematic reviews of marine bird bycatch in the eastern North Sea (Žydelis et al., 2009 and 2013, Oliveira et al., 2015). There are few studies or data on bird bycatch by anchored nets and lines fisheries in the UK (ICES, 2013) other than Northridge et al. (2020). As such, studies from other areas have been used and caution must be applied when interpreting their results.

Žydelis et al. (2013) assert that the true number of birds being killed annually by gillnets worldwide is very likely much higher than bycatch estimates as data was lacking for several regions, some birds fall out of the net or are scavenged before they can be counted towards bycatch figures, and lost gillnets continue to ghost fish and kill birds.

The literature tends to focus on quantifying the bycatch from gillnets and longlines locally and the methods used make the estimation of the population effects of this bycatch difficult (Žydelis et al., 2009). Reports quantifying marine bird bycatch often come from short-term studies and *ad hoc* observations, there is a lack of systematic and continuous monitoring (Žydelis et al., 2013). Bycatch mortality estimates obtained from local areas cannot be extrapolated to other areas because of high levels of bycatch variability due to fleet characteristics and bird abundance (Cortés et al., 2017).

Many evidence sources are studies from the Mediterranean and United States due to a lack of studies in the UK. This must be considered when understanding how applicable evidence is to UK fisheries. For example, longline fisheries overseas may fish for different species to those in the UK and therefore use different sized hooks, which would affect the susceptibility of marine birds to being hooked, with larger hooks thought to be more difficult to swallow (Moreno et al., 1996).

There is relatively little data on the under 10 m vessel longline fishery. For example, the study completed by Northridge et al. (2020) lacked data for this vessel group operating longlines in the English Channel and North Sea. Northridge et al. (2020) observed over 100 hauls of the longline fishery in the northern North Sea and western UK waters (ICES divisions Via and 7bcj), which is targeted by larger vessels. Northridge et al. (2020) bycatch estimates are confined to this fishery due to the vast majority of their data having been collected from it.

9.4 Knowledge gaps: traps

There is limited evidence on the bycatch risk posed to marine birds from traps, which may be due to it being low risk or understudied. Evidence around the impacts of fishing gear on marine birds through impacts to their supporting habitats is lacking. Whilst evidence is available for direct impacts of fishing gear to particular habitats, this is not linked to the resulting impact on marine bird populations. Studies on impacts of fishing on prey availability are also minimal and therefore assumptions have to be made with regards to species caught by gear types and resulting impacts on marine birds.

9.5 Knowledge gaps: fishing vessel presence

Many papers studying vessel presence impacts to marine birds are in relation to shipping, transportation and vessels associated with windfarms; it is noted that fishing vessels are more unpredictable in terms of speed and course so their disturbance potential towards marine birds may vary (Schwemmer et al., 2011). There are limited studies on disturbance caused by fishing activity. Marine bird disturbance caused by windfarms is more commonly studied and this evidence is treated with caution due to the different nature of windfarm activities compared to fishing. Studies commonly record escape distances and disturbance incidents for marine birds but evidence around the long-term disturbance effects is lacking. There is also limited evidence around the impacts of above and underwater noise on marine bird species out at sea, with many noise disturbance studies being focused on the impacts on marine bird nesting colonies. Offshore studies are focused on disturbance as a whole rather than specific impacts of noise and visual stimuli.

Whilst evidence exists around the sensitivity of marine bird species to disturbance from vessels, for example records of escape distances, an evidence gap is understanding the metabolic costs of these behavioural responses (Jarrett et al., 2017). Studies are also needed to understand responses to differences in engine noise and vessel speeds (Schwemmer et al., 2011).

10 Variation in impacts

This section discusses how the potential impacts of different fishing gears (and vessel presence) on marine bird features may vary and be dependent on a wide range of variables.

10.1 Factors affecting all pressures

The impacts of all fishing gears (plus fishing vessel presence), and all associated pressures on marine birds will be dependent on a number of factors, particularly those associated with fishing activity. The level of fishing intensity is likely to cause variation in impacts from the gear types on the designated features and supporting habitats. Greater fishing intensities may increase the risk of marine bird bycatch and change to prey availability from all gear types. Additionally, greater fishing intensity from bottom tower gear can increase changes in water clarity and physical loss or damage to supporting habitats. Regional differences in species targeted by bottom towed gear and/or midwater gear may cause variation in impacts to prey availability. The ability of marine bird species to adapt to changes in prey availability will also lead to variation in impacts.

The occurrence of fishing activity in relation to the distribution of marine birds and location of feeding grounds will cause variation in impacts. For example, marine birds will be at higher risk from bycatch and impacts to prey availability if feeding in areas where midwater or bottom towed gear is being operated.

10.2 Factors affecting marine bird bycatch impacts

Variation in impacts from fishing gears on marine bird bycatch will likely depend on factors such as age and breeding behaviour of marine bird species. For example, bycatch impacts on marine bird populations may be greater if bycaught individuals are adults and monogamous breeding behaviour results in breeding failure for that season, or potentially longer (Bradbury et al., 2017). The use of methods aiming to reduce bycatch in fisheries, for example reducing surface time of midwater and bottom towed trawls, will also cause variation in impacts. The occurrence of marine bird bycatch is also highly likely to fluctuate inter-annually and seasonally due to environmental variability and different intra-annual stages of marine birds, for example, breeding and migration (Kaiser et al., 2002; Lewison and Crowder, 2003).

For vessels operating midwater or bottom towed gear, the attraction of marine birds to foraging opportunities will drive variation in marine bird bycatch, with the exception of red-throated divers for bottom towed gear. Vessels that discharge fisheries waste increase the likelihood of attraction compared to those holding waste onboard (Pierre et al., 2010).

For traps specifically, the depth at which gears are set and whether this is within the diving range of marine bird species and near to marine bird concentrations will cause variation in bycatch risk for marine birds (Shester and Micheli, 2011). Typical diving depths of species have been used to consider potential impacts; however, this may vary between individuals.

The main factors influencing bycatch of marine birds in gillnet fisheries are mesh size, setting depth, time of day, soak time, water clarity, weather conditions, the behaviour of marine bird species, and the setting location in relation to seabird abundance (Tasker et al., 2000, Warden, 2010, Žydelis et al., 2013). The soak durations of gillnets can cause the level of bycatch in common and red-throated diver to vary. Warden's (2010) model estimated that nets with long soak times (over 24 hours) or short haul times (under 30 minutes) had higher bycatch of divers than nets with short soak times or long haul duration. These nets were also located closer to the coast and therefore had a greater chance of interacting with divers (Warden, 2010). The model also estimated gillnets without spaces in between to have 4.6 times higher bycatch than those with spaces, as these spaces could allow birds to pass through the gillnet string (Warden, 2010).

The main factors influencing bycatch of marine birds in longline are season, time of day, bait type, wind conditions, gear configuration, proximity to breeding colony, and number of hooks (Anderson et al., 2011, Cortés et al., 2017). A study by Zhou et al. (2019) found higher marine bird relative abundance could increase bycatch rates in a pelgaic longline fishery. Therefore, bycatch rates could be higher in fisheries operating near breeding sites or feeding areas where marine birds occur in high numbers. Larger species were also more susceptible to longline bycatch, which could lead to a skewed marine bird mortality to larger adult marine birds (Zhou et al., 2019). Any factor increasing the adult mortality rate can have a strong detrimental effect on population dynamics (Furness, 2003). Setting longlines during daylight hours has been shown to increase the probability of bycatch in the north-western Mediterranean (Cortés et al., 2017). Several studies of the same area of the Mediterranean Sea found that bycatch rates were highest during marine bird breeding season (Belda and Sánchez, 2001, Garcia-Barcelona et al., 2010, Laneri et al., 2010, Cortes et al, 2017).

10.3 Factors affecting prey availability impacts

Marine birds are more likely to be impacted by prey availability during the breeding season during which they are central place foragers (feeding at sea, but having to regularly return to their breeding site for duties such as nest defence, egg incubation and chick provisioning) (Ponchon et al., 2019). If prey is not available, these species may feed further afield which could lead to reduced reproductive output and lower adult survival (Tasker et al., 2000; Goyert, 2014). During the non-breeding season, marine birds will not have the same geographical constraints and parental care responsibilities as in the breeding season (Duckworth et al., 2021), meaning they may be able to adapt to localised reductions in prey by feeding elsewhere. Tern species covered in this review are protected during the breeding season and therefore may be more susceptible to changes in prey availability. Red-throated diver, little gull and common scoter are protected during the non-breeding season, suggesting that impacts may be of lower concern.

10.4 Factors affecting impacts of changes in suspended solids (water clarity)

Natural background turbidity levels may cause variations in the impact of changes to water clarity caused by fishing (van Kruchten and van der Hammen, 2011).

10.5 Factors affecting non-physical disturbance impacts

The nature, scale, intensity and duration of fishing activities will cause variation in the magnitude of the pressure caused by visual and noise disturbance from fishing vessels (Natural England and JNCC, 2021). Noise and visual disturbance and associated impacts may vary depending on the type and size of the vessel (Bellebaum et al., 2006). The speed of vessels is also a factor which will impact the probability of disturbance, with speed being shown to be closely linked to the range and duration of displacement of marine birds (Burger et al., 2019; Ronconi and Clair, 2002). Burger et al. (2019) found the most disturbance to red-throated divers to occur from high-speed vessels (over 40 km/hour).

The type of species present and age may cause variation in impacts (Natural England and JNCC, 2021). Wing morphology may cause inter-specific variation, it is thought that species with higher body mass and wing loading may be more reluctant to take off due to high energy costs, which may result in lower escape distances (Schwemmer et al., 2011). Intra-specific variation in disturbance response and associated escape distances may be caused by the flock size, location of the flock in relation to vessels, the sea state and moulting stage of marine birds (Kaiser et al., 2002; Natural England and JNCC, 2021; Schwemmer et al., 2011). Food availability is a key factor in determining whether marine bird species are present where fishing vessels occur and therefore whether species are at risk from disturbance (Schwemmer et al., 2011). Where prey availability is lacking, birds may be more inclined to forage in association with vessels.

Habituation of marine birds to disturbance caused by vessels may cause variation in impacts (Natural England and JNCC, 2021). Whilst habituation to shipping channels has been found for some species, data suggests that common scoter and red-throated divers do not habituate and it is questioned whether habituation would occur for free-ranging vessels such as fishing vessels as they are unpredictable in nature (Schwemmer et al., 2011).

Tide height has been identified as a factor that affects marine bird distribution, with some species being more vulnerable to vessel disturbance when foraging further from shore during low tide (Ronconi and Clair, 2002). Energy requirements of marine birds are typically highest during periods of chick rearing, so minimal disturbance levels during this phase is likely to increase reproductive success (Dunnet et al., 1990). Marine birds are most vulnerable to disturbance during periods of higher colony attendance and foraging activity, or certain phases of the breeding season (Ronconi and Clair, 2002).

11 Document summary

For each MPA protecting marine birds, a site level assessment will be needed to assess fishing activities for their impact upon these areas. The data used in the assessment will include vessel monitoring system (VMS) data, as well as feature data from JNCC and Natural England. The assessments will consider the potential for these activities to have an adverse effect on the site integrity of the MPA. If an adverse effect cannot be ruled out, then management measures will need to be considered. MMO has regard to the best available evidence and through consultation with relevant advisors, stakeholders, and the public, will conclude which management option is implemented.

Site level assessments will consider the context of other existing and developing management mechanisms. Wider measures may be relevant to managing impacts of pressures discussed on marine birds in MPAs. Examples of wider management measures are summarised below:

- UK Seabird Bycatch Plan of Action (in development, not yet published) – will outline actions to work towards its overarching aim to minimise, and where possible, eliminate marine bird bycatch in UK fisheries (Clean Catch UK, 2021);
- quota management;
- control measures for the size/types of gears; and
- English Seabird Conservation Strategy (in development, not yet published).

MMO will consider these, and consult with relevant advisors, stakeholders, and the public before making any management decisions, however any management must meet requirements of site level conservation objectives.

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Annex 1 - Gear pressures on marine birds

This annex summarises the pressures of each gear type and vessel presence on the features described in this document.

JNCC and Natural England's advice on operations (AoO) provide generic information on pressures that may be exerted by all marine industries, they are an evidence-based product to be used to guide assessments together with bespoke advice from JNCC and Natural England. This is explained further in Natural England's conservation advice guidance.

The sensitivities of designated features to gear and vessel presence pressures were derived using a staged approach. JNCC and Natural England's conservation advice packages (CAP) and AoO have been used by MMO to determine the sensitivities of each feature to the potential pressures from each gear type and vessel presence, based on actual or representative sites to highlight subject areas for evidence gathering. JNCC and Natural England also provided additional guidance about pressure/feature interactions that should be considered.

An evidence-gathering activity was then carried out. Evidence gathering and analysis was focussed on interactions that were deemed sensitive and high risk, as these are likely to be the most relevant interactions to be considered at each site level assessment (Table A1. 1).

Interactions marked as IE or S* are only considered further where advice from JNCC or Natural England supports doing so. Other interactions marked as IE will be considered in site level assessments where there is a known condition issue or further advice is received from JNCC or Natural England (Table A1. 1).

The potential pressures from each gear type and vessel presence are displayed in tables A1. 2 to A1. 6. These tables summarise all the interactions according to the key in Table A1. 1. The pressures listed in tables A1. 2 to A1. 6. are defined in JNCC AoO descriptions of pressures, based on Appendix 1 of the UK Marine Pressures-Activities Database 'PAD': Methods Report | JNCC Resource Hub (Robson et al., 2018).

Waterbird assemblages are not included in these tables. It is assumed that the same pressures will also be potential pressures for the other species and waterbird assemblage feature covered in this review.

A1. 1. Gear/feature interaction sensitivity key. Pressures discussed within this review will be shown in red.

Key	
S	Indicates the feature is sensitive.
S*	Indicates the feature is sensitive to the pressure in general, but fishing activity/gear type is unlikely to exert that pressure to an extent where impacts are of concern (i.e., will be below pressure benchmarks).
IE	Indicates there is insufficient evidence to make sensitivity conclusions or a sensitivity assessment has not been made for this feature to this pressure.
NS	Indicates feature is not sensitive to pressure.
NR	Indicates the pressure is not relevant for the gear type. There is no interaction between the pressure and biotope/species and/or no association between the activity and the pressure.
NA	Indicates that a sensitivity assessment has not been made for this feature to this pressure.

Bottom towed gear

A1. 2. Summary of the sensitivities of designated features to potential pressures from bottom towed gear. Pressures discussed within this review are shown in red. CT = Common tern; LT = Little tern; RTD = Red-throated diver; ST = Sandwich tern; CS = Common scoter; LG = Little gull; SH = Supporting habitat.

	Features							
Potential Pressures	**CT**	**LT**	**RTD**	**ST**	**CS**	**LG**	**SH**	**Justification**
Abrasion/disturbance of the substrate on the surface of the seabed	NS	NS	NS	NR	NS	NR	NR/ S	Some or all of the supporting habitats relevant to the designated species may be sensitive to these pressures. Assessed under physical loss, change or damage to supporting habitats.
Penetration and/or disturbance of the substratum below the surface of the seabed, including abrasion	NR	NR	NR	NR	NR	NR	NR/ S	
Smothering and siltation rate changes (light)	NR	NR	NR	NR	NR	NR	NR/ NS/ S	
Changes in suspended solids (water clarity)	S	S	S	S	S	S	NR/ NS/ S	Marine bird species and some or all of the supporting habitats relevant to the designated species may be sensitive to this pressure. Assessed under changes in suspended solids (water clarity) and physical loss, change or damage to supporting habitats.
Marine bird bycatch (removal of non-target species)	S	S	S	S	S	S	NR/ S	Marine bird species and some or all of the supporting habitats relevant to the designated species may be sensitive to this pressure. Marine bird species impacts assessed under marine bird bycatch (removal of non-target species). Species associated with supporting habitats assessed under removal of target and non-target prey species.

	Features							
Potential Pressures	**CT**	**LT**	**RTD**	**ST**	**CS**	**LG**	**SH**	**Justification**
Removal of target and non-target prey species	NR	NR	NR	NR	NR	NR	NR/ S	Some or all of the supporting habitats relevant to the designated species may be sensitive to this pressure. Assessed under removal of target and non-target prey species.
Physical change (to another sediment type)	NR	NR	NR	NR	NR	NR	NR/ S*	Some or all of the supporting habitats relevant to the designated species may be sensitive to this pressure. Assessed under physical loss, change or damage to supporting habitats.
Above water noise	S	S	S	S*	S*	S*	NR	Some marine bird species and some or all of the supporting habitats relevant to the designated species may be sensitive to these pressures. Assessed in the fishing vessel presence review.
Underwater noise changes	IE	IE	S*	IE	NS	IE	NR/ NS/ IE/ S*	
Visual disturbance	S	S	S	S	S	NS	NR/ NS/ S	
Collision ABOVE/BELOW water with static or moving objects not naturally found in the marine environment (for example boats, machinery, and structures)	S	S	S	S*	S*	S*	NR	Marine bird species may be sensitive to this pressure. This pressure is assessed in the fishing vessel presence review. Collision risk with fishing gear is covered by removal of non-target species (marine bird bycatch).
Hydrocarbon and PAH contamination	NA	NA	NA	NA	NA	NA	NR/ NA	The sensitivity of the features has not been assessed for this pressure. However, deliberate releases are already prohibited and accidental discharges from fishing vessels leading to significant releases are extremely rare. Exposure to this pressure is very unlikely for marine birds. This pressure will therefore not be covered in this review.

	Features							
Potential Pressures	**CT**	**LT**	**RTD**	**ST**	**CS**	**LG**	**SH**	**Justification**
Introduction of light	IE	IE	S*	S*	S*	IE	NR/ NS/ IE/ S*	Red-throated diver, Sandwich tern, common scoter and some or all of the supporting habitats relevant to the designated species may be sensitive to this pressure. For the remaining species there is insufficient evidence to assess. Advice from the Statutory Nature Conservation Bodies is that this pressure is not likely to pose a particular risk to the features considered in this review, however the lack of evidence regarding this pressure is noted and it may be revisited if new evidence becomes available. This pressure will not be covered in this review.
Introduction or spread of invasive non-indigenous species	S*	S*	NS	NS	S*	NS	NR/ NS/ S*	Common tern, little tern, common scoter and some or all of the supporting habitats relevant to the designated species may be sensitive to this pressure, however, this pressure is low risk for offshore sites and more relevant to coastal marine bird nesting sites where predatory species may be introduced. This pressure will therefore not be covered in this review.
Litter	S*	S*	S*	S*	S*	S*	NR/ NA/ S*	Marine bird species and some or all of the supporting habitats relevant to the designated species may be sensitive to this pressure. There may be site specific instances where litter derived from fishing vessels or ghost gears have an impact, however, this pressure is not appropriate to manage in a localised way at MPA level for fisheries only. International legislation is in place, such as Annex V of the International Convention for the Prevention of Pollution from Ships 1973 (International Maritime Organization, 2019). This pressure will therefore not be covered in this review.
Deoxygenation	NR	NR	NR	NR	NR	NR	NR/ NS /IE/ S*	Some or all of the supporting habitats relevant to the designated species may be sensitive to these pressures, however, any changes are likely to be relatively short-lived and localised so unlikely to impact marine bird species. These pressures will therefore not be covered in this review.
Nutrient enrichment	NR	NR	NR	NR	NR	NR	NR/ NS/	

	Features							
Potential Pressures	**CT**	**LT**	**RTD**	**ST**	**CS**	**LG**	**SH**	**Justification**
							IE/ S*	
Organic enrichment	NR	NR	NR	NR	NR	NR	NR/ NS/IE/S*	
Physical change (to another seabed type)	NR	NR	NR	NR	NR	NR	NR/ S*	Some or all of the supporting habitats relevant to the designated species may be sensitive to this pressure, however this is pressure is more relevant to activities such as installation of infrastructure and removal of substrata. This pressure will therefore not be covered in this review.
Synthetic compound contamination (incl. pesticides, antifoulants, pharmaceuticals)	NA	NA	NA	NA	NA	NA	NR/ NA	The sensitivity of features has not been assessed for these pressures. Management of these pressures occur through legislation such as the International Convention for the Prevention of Pollution from Ships 1973 (International Maritime Organization, 2019). Exposure to this pressure is very unlikely for marine birds. These pressures will therefore not be covered in this review.
Transition elements and organo-metal (e.g. TBT) contamination	NA	NA	NA	NA	NA	NA	NR/ NA	

Midwater gear

A1. 3: Summary of the sensitivities of designated features to potential pressures from midwater gear. Pressures discussed within this review are shown in red. CT = Common tern; LT = Little tern; RTD = Red-throated diver; ST = Sandwich tern; CS = Common scoter; LG = Little gull; SH = Supporting habitat.

	Features							
Potential Pressures	**CT**	**LT**	**RTD**	**ST**	**CS**	**LG**	**SH**	**Justification**
Marine bird bycatch (removal of non-target species)	S	S	S	S	S	S	NR/ S	Marine bird species and some or all of the supporting habitats relevant to the designated species may be sensitive to this pressure. Marine bird species impacts assessed under marine bird bycatch (removal of non-target species). Species associated with supporting habitats assessed under removal of target and non-target prey species
Removal of target and non-target prey species	NR	NR	NR	NR	NR	NR	NR/ S	Some or all of the supporting habitats relevant to the designated species may be sensitive to this pressure. Assessed under removal of target and non-target prey species.
Above water noise	S	S	S	S*	S*	S*	NR	Marine bird species and some or all of the supporting habitats relevant to the designated species may be sensitive to these pressures. These pressures will be assessed in the fishing vessel presence review.
Underwater noise changes	IE	IE	S*	NS	NA	IE	NR/ S	
Visual disturbance	S	S	S	S*	S*	NS	NR/ S*	
Barrier to species movement	NS	S*	S*	NS	S*	S*	NR/ S*	Little tern, red-throated diver, common tern, little gull and some or all of the supporting habitats relevant to the designated species may be sensitive to this pressure, however, this pressure is more relevant to artificial structures, for example related to offshore windfarm development. This pressure will therefore not be covered in this review.
Collision ABOVE/BELOW water with static or moving objects not naturally	S	S	S	S*	S*	S*	NR	Marine bird species may be sensitive to this pressure. This pressure is assessed in the fishing vessel presence review. Collision risk with fishing gear is covered by removal of non-target species (marine bird bycatch).

	Features							
Potential Pressures	**CT**	**LT**	**RTD**	**ST**	**CS**	**LG**	**SH**	**Justification**
found in the marine environment (for example boats, machinery, and structures)								
Hydrocarbon and PAH contamination	NA	NA	NA	NA	NA	NA	NR/ NA	The sensitivity of features has not been assessed for this pressure. However, deliberate releases are already prohibited and accidental discharges from fishing vessels leading to significant releases are extremely rare. Exposure to this pressure is very unlikely for marine birds. This pressure will therefore not be covered in this review.
Introduction of light	IE	IE	S	IE	S*	IE	NR/ S*	Red-throated diver, common scoter and some or all of the supporting habitats relevant to the designated species may be sensitive to this pressure. There is insufficient evidence for the other bird species. Advice from the Statutory Nature Conservation Bodies is that this pressure is not likely to pose a particular risk to the features considered in this review, however the lack of evidence regarding this pressure is noted and it may be revisited if new evidence becomes available. This pressure will not be covered in this review.
Introduction or spread of invasive non-indigenous species	S	S	NS	S*	NS	NS	NR/ S	Common tern, little tern, common scoter and some or all of the supporting habitats relevant to the designated species may be sensitive to this pressure, however, this pressure is low risk for offshore sites and more relevant to coastal marine bird nesting sites where predatory species may be introduced. This pressure will therefore not be covered in this review.
Litter	S	S	S	S*	S*	S*	NR/ S	Marine bird species and some or all of the supporting habitats relevant to the designated species may be sensitive to this pressure. There may be site specific instances where litter derived from fishing vessels or ghost gears have an impact, however, this pressure is not

Potential Pressures	Features: CT	LT	RTD	ST	CS	LG	SH	Justification
								appropriate to manage in a localised way at MPA level for fisheries only. International legislation is in place, such as Annex V of the International Convention for the Prevention of Pollution from Ships 1973 (International Maritime Organization, 2019). This pressure will therefore not be covered in this review.
Deoxygenation	NR	NR	NR	NR	NR	NR	NR/S	Some or all of the supporting habitats relevant to the designated species may be sensitive to these pressures, however, any changes are likely to be relatively short-lived and localised so unlikely to impact marine bird species. These pressures will therefore not be covered in this review.
Organic enrichment	NR	NR	NR	NR	NR	NR	NR/S	
Synthetic compound contamination (incl. pesticides, antifoulants, pharmaceuticals)	NA	NA	NA	NA	NA	NA	NR/NA	The sensitivity of marine bird features has not been assessed for this pressure. Management of these pressures occur through legislation such as the International Convention for the Prevention of Pollution from Ships 1973 (International Maritime Organization, 2019). Exposure to this pressure is very unlikely for marine birds. These pressures will therefore not be covered in this review.
Transition elements and organo-metal (e.g. TBT) contamination	NA	NA	NA	NA	NA	NA	NR/NA	

Anchored nets and lines

A1. 4: Summary of the sensitivities of designated features to potential pressures from anchored nets and lines. Pressures discussed within this review are shown in red. CT = Common tern; LT = Little tern; RTD = Red-throated diver; ST = Sandwich tern; CS = Common scoter; LG = Little gull; SH = Supporting habitat.

	Features							
Potential Pressures	**CT**	**LT**	**RTD**	**ST**	**CS**	**LG**	**SH**	**Justification**
Abrasion/disturbance of the substrate on the surface of the seabed	NR	NR	NR	NR	NR	NR	NR/ S	Some or all of the supporting habitats relevant to the designated species may be sensitive to this pressure. Assessed under physical loss, change or damage to supporting habitats.
Penetration and/or disturbance of the substratum below the surface of the seabed, including abrasion	NR	NR	NR	NR	NR	NR	NR/ S	
Marine bird bycatch (removal of non-target species)	S	S	S	S	S	S	NR/ S	Marine bird species and some or all of the supporting habitats relevant to the designated species may be sensitive to this pressure. Marine bird species impacts assessed under marine bird bycatch (removal of non-target species). Species associated with supporting habitats assessed under removal of target and non-target prey species.
Removal of target and non-target prey species	NR	NR	NR	NR	NR	NR	NR/ S	Supporting habitats may be sensitive to this pressure. Assessed under removal of target and non-target prey species.
Above water noise	S	S	S	S	S	S	NR	Marine bird species and some or all of the supporting habitats relevant to the designated species may be sensitive to this pressure. Assessed in the fishing vessel presence review.
Underwater noise changes	IE	IE	S*	NS	NA	IE	NR/ S	

	Features							
Potential Pressures	**CT**	**LT**	**RTD**	**ST**	**CS**	**LG**	**SH**	**Justification**
Visual disturbance	S	S	S	S*	S*	NS	NR/ S*	
Barrier to species movement	NS	S*	S*	NS	S*	S*	NR/ NS/ S*	Little tern, red-throated diver, common tern, little gull and some or all of the supporting habitats relevant to the designated species may be sensitive to this pressure, however, this pressure is more relevant to artificial structures, for example related to offshore windfarm development. This pressure will therefore not be covered in this review.
Collision ABOVE/BELOW water with static or moving objects not naturally found in the marine environment (for example boats, machinery, and structures)	S	S	S	S	S	S	NR	Marine bird species may be sensitive to this pressure. This pressure is assessed in the fishing vessel presence review. Collision risk with fishing gear is covered by removal of non-target species (marine bird bycatch).
Hydrocarbon and PAH contamination	NA	NA	NA	NA	NA	NA	NR/ NA	The sensitivity of features has not been assessed for this pressure. However, deliberate releases are already prohibited and accidental discharges from fishing vessels leading to significant releases are extremely rare. Additionally, fishing as standard practice would not exert at the pressure benchmarks. This pressure will therefore not be covered in this review.
Introduction of light	IE	IE	S	IE	S*	IE	NR/ NS/ IE/ S*	Red-throated diver, common scoter and some or all of the supporting habitats relevant to the designated species may be sensitive to this pressure. There is insufficient evidence for the other bird species. Advice from the Statutory Nature Conservation Bodies is that this pressure is not likely to pose a particular risk to the features considered in this review, however the lack of evidence

	Features							
Potential Pressures	**CT**	**LT**	**RTD**	**ST**	**CS**	**LG**	**SH**	**Justification**
								regarding this pressure is noted and it may be revisited if new evidence becomes available. This pressure will not be covered in this review.
Introduction or spread of invasive non-indigenous species	S	S	NS	S*	NS	NS	NR/ NS/ S	Common tern, little tern, Sandwich tern and some or all of the supporting habitats relevant to the designated species may be sensitive to this pressure, however, this pressure is low risk for offshore sites and more relevant to coastal marine bird nesting sites where predatory species may be introduced. This pressure will therefore not be covered in this review.
Litter	S	S	S	S*	S*	S*	NR/ NA/ S	Marine bird species and some or all of the supporting habitats relevant to the designated species may be sensitive to this pressure. There may be site specific instances where litter derived from fishing vessels or ghost gears have an impact, however, this pressure is not appropriate to manage in a localised way at MPA level for fisheries only. International legislation is in place, such as Annex V of the International Convention for the Prevention of Pollution from Ships 1973 (International Maritime Organization, 2019). This pressure will therefore not be covered in this review.
Deoxygenation	NR	NR	NR	NR	NR	NR	NR/ NS/ S	Some or all of the supporting habitats relevant to the designated species may be sensitive to this pressure, however, any changes are likely to be relatively short-lived and localised so unlikely to impact marine bird species. These pressures will therefore not be covered in this review.
Organic enrichment	NR	NR	NR	NR	NR	NR	NR/ NS/ S	

	Features							
Potential Pressures	**CT**	**LT**	**RTD**	**ST**	**CS**	**LG**	**SH**	**Justification**
Synthetic compound contamination (incl. pesticides, antifoulants, pharmaceuticals)	NA	NA	NA	NA	NA	NA	NR/ NA	The sensitivity of features has not been assessed for these pressures. Management of these pressures occur through legislation such as the International Convention for the Prevention of Pollution from Ships 1973 (International Maritime Organization, 2019). Exposure to this pressure is very unlikely for marine birds. These pressures will therefore not be covered in this review.
Transition elements and organo-metal (e.g. TBT) contamination	NA	NA	NA	NA	NA	NA	NR/ NA	

Traps

A1. 5: Summary of the sensitivities of designated features to potential pressures from traps. Pressures discussed within this review are shown in red. CT = Common tern; LT = Little tern; RTD = Red-throated diver; ST = Sandwich tern; CS = Common scoter; LG = Little gull; SH = Supporting habitat.

	Features							
Potential Pressures	**CT**	**LT**	**RTD**	**ST**	**CS**	**LG**	**SH**	**Justification**
Abrasion/disturbance of the substrate on the surface of the seabed	NR	NR	NR	NR	NR	NR	NR/ S	Some or all of the supporting habitats relevant to the designated species may be sensitive to this pressure. Assessed under physical loss, change or damage to supporting habitats.
Marine bird bycatch (removal of non-target species)	S	S	S	S	S	S	NR/ S	Marine bird species and some or all of the supporting habitats relevant to the designated species may be sensitive to this pressure. Marine bird species impacts assessed under marine bird bycatch (removal of non-target species). Species associated with supporting habitats assessed under removal of target and non-target prey species.
Removal of target and non-target prey species	NR	NR	NR	NR	NR	NR	NR/ S	Some or all of the supporting habitats relevant to the designated species may be sensitive to this pressure. Assessed under removal of target and non-target prey species.
Above water noise	S	S	S	S*	S*	S*	NR	Marine bird species and some or all of the supporting habitats relevant to the designated species may be sensitive to these pressures. Assessed in the fishing vessel presence review.
Underwater noise changes	IE	IE	S*	IE	NS	IE	NR/ NS/ IE/ S	
Visual disturbance	S	S	S	S*	S*	NS	NR/ NS/ S*	
Barrier to species movement	NS	S*	S*	NS	S*	S*	NR/ NS/ S*	Little tern, red-throated diver, common scoter, little gull and some or all of the supporting habitats relevant to the designated species may be sensitive to this pressure, however, this pressure is more

Potential Pressures	CT	LT	RTD	ST	CS	LG	SH	Justification
	Features							
								relevant to artificial structures, for example related to offshore windfarm development. This pressure will therefore not be covered in this review.
Collision ABOVE/BELOW water with static or moving objects not naturally found in the marine environment (for example boats, machinery, and structures)	S	S	S	S	S	S	NR	Marine bird species may be sensitive to this pressure. This pressure is assessed in the fishing vessel presence review. Collision risk with fishing gear is covered by removal of non-target species (marine bird bycatch).
Hydrocarbon and PAH contamination	NA	NA	NA	NA	NA	NA	NA/ NR	The sensitivity of features has not been assessed for this pressure. However, deliberate releases are already prohibited and accidental discharges from fishing vessels leading to significant releases are extremely rare. Exposure to this pressure is very unlikely for marine birds. This pressure will therefore not be covered in this review.
Introduction of light	IE	IE	S	IE	S*	IE	NR/ NS/ IE/ S*	Red-throated diver, common scoter and some or all of the supporting habitats relevant to the designated species may be sensitive to this pressure. There is insufficient evidence for the remaining bird species. Advice from the Statutory Nature Conservation Bodies is that this pressure is not likely to pose a particular risk to the features considered in this review, however the lack of evidence regarding this pressure is noted and it may be revisited if new evidence becomes available. This pressure will not be covered in this review.
Introduction or spread of invasive non-indigenous species	S	S	NS	S*	NS	NS	NR/ NS/ S	Common tern, little tern, Sandwich tern and some or all of the supporting habitats relevant to the designated species may be sensitive to this pressure, however, this pressure is low risk for

	Features							
Potential Pressures	**CT**	**LT**	**RTD**	**ST**	**CS**	**LG**	**SH**	**Justification**
								offshore sites and more relevant to coastal marine bird nesting sites where predatory species may be introduced. This pressure will therefore not be covered in this review.
Litter	S	S	S	S*	S*	S*	NR/ NA/ S	Marine bird species and some or all of the supporting habitats relevant to the designated species may be sensitive to this pressure. There may be site specific instances where litter derived from fishing vessels or ghost gears have an impact, however, this pressure is not appropriate to manage in a localised way at MPA level for fisheries only. International legislation is in place, such as Annex V of the International Convention for the Prevention of Pollution from Ships 1973 (International Maritime Organization, 2019). This pressure will therefore not be covered in this review.
Deoxygenation	NR	NR	NR	NR	NR	NR	NR/ NS/ IE/ S	Some or all of the supporting habitats relevant to the designated species may be sensitive to this pressure, however, any changes are likely to be relatively short-lived and localised so unlikely to impact marine bird species. These pressures will therefore not be covered in this review.
Organic enrichment	NR	NR	NR	NR	NR	NR	NR/ NS/ IE/ S	
Synthetic compound contamination (incl. pesticides, antifoulants, pharmaceuticals)	NA	NA	NA	NA	NA	NA	NR/ NA	The sensitivity of features has not been assessed for these pressures. Management of these pressures occur through legislation such as the International Convention for the Prevention of Pollution from Ships 1973(International Maritime Organization, 2019). Exposure to this pressure is very unlikely for marine birds. These pressures will therefore not be covered in this review.
Transition elements and organo-metal (e.g. TBT) contamination	NA	NA	NA	NA	NA	NA	NR/ NA	

Vessel presence

A1. 6: Summary of the sensitivities of designated features to potential pressures from fishing vessel presence. Pressures discussed within this review are shown in red. CT = Common tern; LT = Little tern; RTD = Red-throated diver; ST = Sandwich tern; CS = Common scoter; LG = Little gull; SH = Supporting habitat.

	Features							
Potential Pressures	**CT**	**LT**	**RTD**	**ST**	**CS**	**LG**	**SH**	**Justification**
Above water noise	S	S	S	S*	S*	S*	NR	Marine bird species and some or all of the supporting habitats may be sensitive to these pressures. These pressures will be assessed in this review under non-physical disturbance.
Underwater noise changes	IE	IE	S*	NS	NA	IE	NR/ S	
Visual disturbance	S	S	S	S	S	NS	NR/ S*	
Introduction of light	IE	IE	S	IE	S*	IE	NR/ S*	Red-throated diver, common scoter and some or all of the supporting habitats relevant to the designated species may be sensitive to this pressure. There is insufficient evidence for the remaining bird species. Advice from the Statutory Nature Conservation Bodies is that this pressure is not likely to pose a particular risk to the features considered in this review, however the lack of evidence regarding this pressure is noted and it may be revisited if new evidence becomes available. This pressure will not be covered in this review.
Collision ABOVE/BELOW water with static or moving objects not naturally found in the marine environment (for example boats, machinery, and structures)	S	S	S	S	S	S	NR	Marine bird species may be sensitive to this pressure. This pressure is assessed in this review. Collision risk with fishing gear is covered by removal of non-target species (marine bird bycatch).