Marine
Management
Organisation

Stage 4 Fishing Gear MPA Impacts Evidence: Harbour Porpoise

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Contents

Executive Summary

This document collates and analyses the best available evidence on the impacts of commercial fishing gears on harbour porpoise. This document will inform site level assessments of the impact of fishing on marine protected areas (MPAs) designated for harbour porpoise 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, nets, lines, traps and midwater gear) and the presence of fishing vessels have the potential to impact harbour porpoise MPA 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 for 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 harbour porpoise (a designated feature within certain MPAs). It describes the potential for pressures and impacts caused by fishing on harbour porpoise by gathering and analysing the available evidence for gear-feature interactions.

There are two MPAs designated to protect harbour porpoise within MMO's jurisdiction:

- Bristol Channel Approaches MPA; and
- Southern North Sea MPA.

MMO has used the Advice on Operations (AoO) for these two MPAs to help inform this analysis (JNCC, 2019c, 2019b). However, the pressures outlined in the AoO are not necessarily specific to pressures exerted by commercial fishing activities nor individual gears. Consequently, MMO - in liaison with the Joint Nature Conservation Committee (JNCC) and Natural England - has used the best available evidence to identify the key pressures exerted by commercial fishing on harbour porpoise, as well as the gear types considered to potentially interact with harbour porpoise. The gear types considered in this review are bottom towed gear (including demersal seines), nets, lines, traps and midwater gear, plus general fishing vessel presence. Please see Section 2 for an overview of these fishing gears and Annex 1 for the key pressures identified for each gear type.

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

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

Natural England's Glossary of terms used within conservation advice packages (CAPs).

The following terms are particularly important 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.

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 harbour porpoise 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 disturbance from vessel operations).

Indirect impacts - the impacts caused to harbour porpoise 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 harbour porpoise. This is referred to as harbour porpoise 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 the prey species of harbour porpoise.

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

- physical change (to another seabed/sediment type);
- abrasion/disturbance to surface substrate;
- penetration and/or disturbance of the substrate below the surface of the seabed; and
- changes in suspended solids (water clarity).

- smothering and siltation rate changes (light).

This document groups these pressures together as these pressures all have the potential to impact the supporting habitats of harbour porpoise (and their associated species).

Management units (MUs) - MUs are geographical areas in which particular species are found and to which management of human activities is applied (IAMMWG, 2023). The boundaries of harbour porpoise MUs are based on the presence of known populations as well as divisions (for example political boundaries) used for management of human activities (IAMMWG, 2023).

Bycatch - the removal of species not targeted by the fishery, in this case, the incidental killing and capture of harbour porpoise. The impacts include mortality (including drowning), injury through entanglement, internal and external injuries, and physical and psychological stress from injuries which can result in long-term health conditions and a shortened life expectancy (IAMMWG et al., 2015; Dolman and Brakes, 2018). Animals that are released or escape alive from fishing gear may still succumb to their injuries, for example through infection (Hamer, 2019).

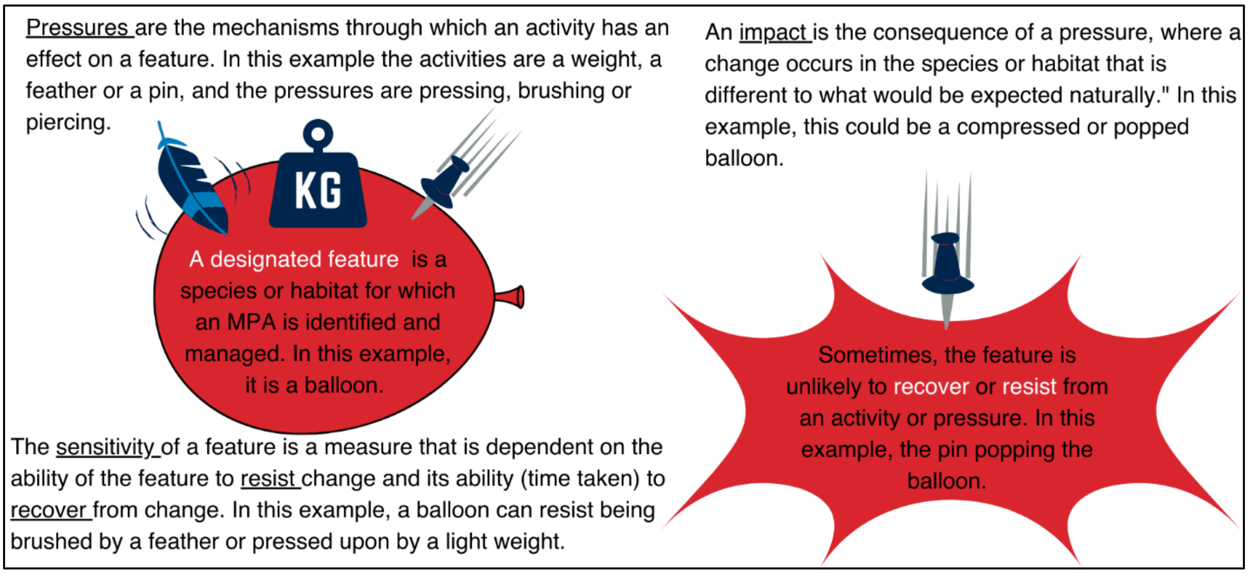

Figure 1. Definitions related to MPA pressures and impacts. Sensitivity information is not available in the Advice on Operations for the full range of fishing gears considered in this document and the pressures potentially exerted by these gears on harbour porpoise. Therefore, we have utilised advice from Natural England and JNCC regarding the relative level of risk of impact of each pressure (see Annex 1).

1.2 Structure of this document

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

Section 3 describes the MPA feature considered, including information on protection, ecology and behaviour.

Sections 4 to 9 describe the available evidence regarding the pressures resulting from different fishing gears or fishing vessel presence on harbour porpoise.

Section 10 provides information on the levels of literature, caveats and assumptions for the evidence included in this document.

Section 11 provides information on variation in impacts.

Annex 1 provides information on the pressures that are 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 harbour porpoise:

- Bottom towed gear
- Nets (gillnets)
- Lines
- Traps
- Midwater gear

Each sub-type of the gear types listed above may have different impacts on harbour porpoise, 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).

[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

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; and
- 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) note 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 gear used.

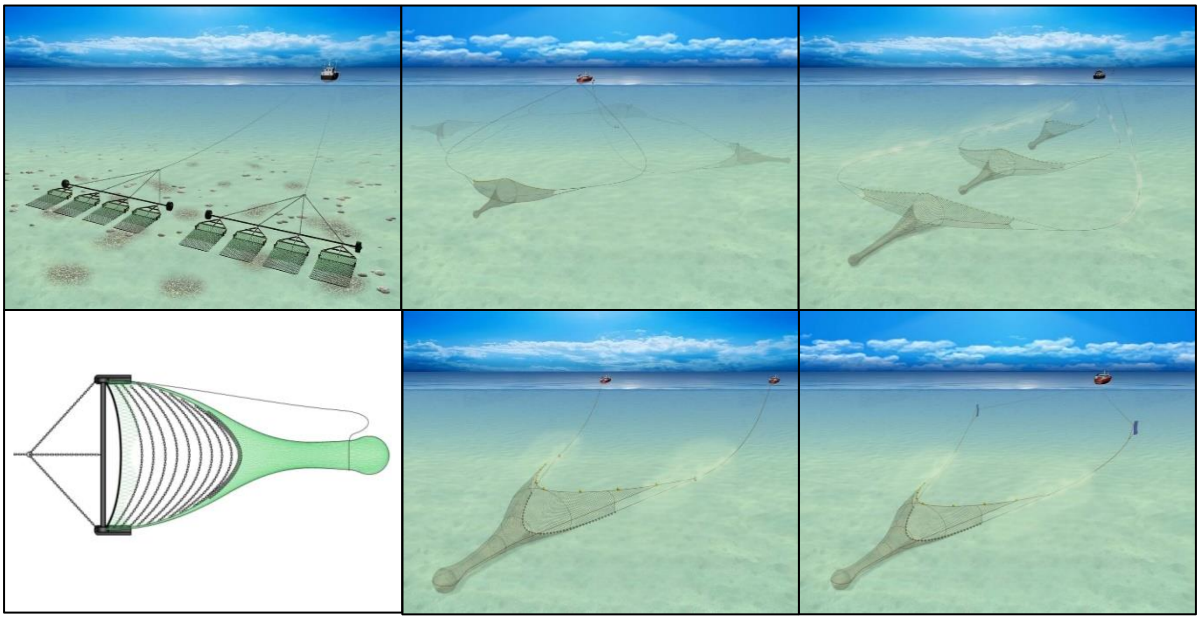

Figure 2. Dredges (top left), anchor seine (top middle), Scottish seine (top right), beam trawl (bottom left), pair trawl (bottom middle), semi-pelagic trawl (bottom right). © Seafish

2.2 Nets (gillnets)

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; Figure 3). 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, 2023c).

2.2.1 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; Figure 3). 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).

2.2.2 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, 2023j). Due to having less flotation, tangle nets generally do not stand as high off the seabed as the average gillnet (Seafish, 2023j). 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, 2023j).

2.2.3 Drift nets

Unlike other types of gillnets, drift nets are not anchored to the seabed but are suspended in the water and allowed to drift (for example with the tide), usually with one end attached to the boat (Montgomerie, 2022). Drift nets are often suspended just below the surface, but can be suspended anywhere from the seabed to the surface (Montgomerie, 2022). The soak time (the length of time the net is in the water) will generally be much shorter for drift nets than for bottom-set gill nets (Montgomerie, 2022). In the UK, drift nets are used on a small scale typically by inshore vessels operating on a seasonal basis targeting small pelagic fish, such as bass; although, other target species include herring, mackerel, salmon and sea trout (Seafish, 2023b).

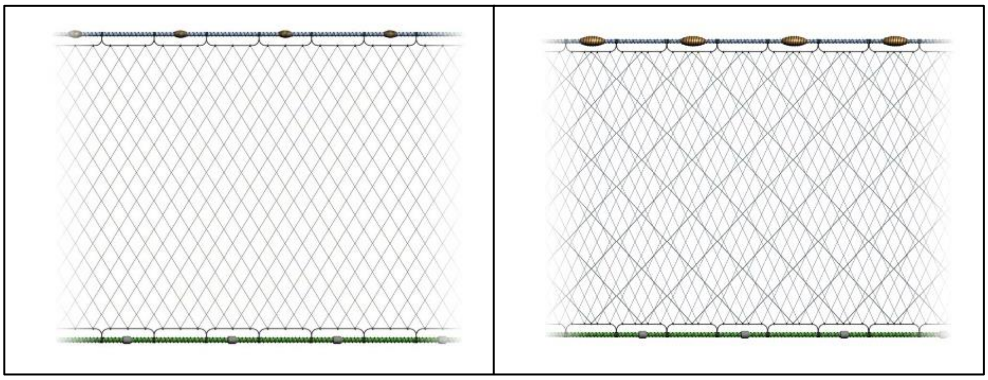

Figure 3. Single walled gill net (left), trammel net (right). © Seafish

2.3 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; and
- 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 fishery. For example, in the UK the main target species for commercial longlines are any demersal species, as well as specifically bass, cod, dogfish, haddock, halibut, ling, pollack, saithe, skates and turbot (Seafish, 2023e). For jigging, the main target species are cod, mackerel, pollock, saithe and squid (Seafish, 2023d), whilst for trolling the main target species tends to be bass (Seafish, 2023l).

This review uses the term ‘lines’ as a collective term to refer to different types of line fishing gear.

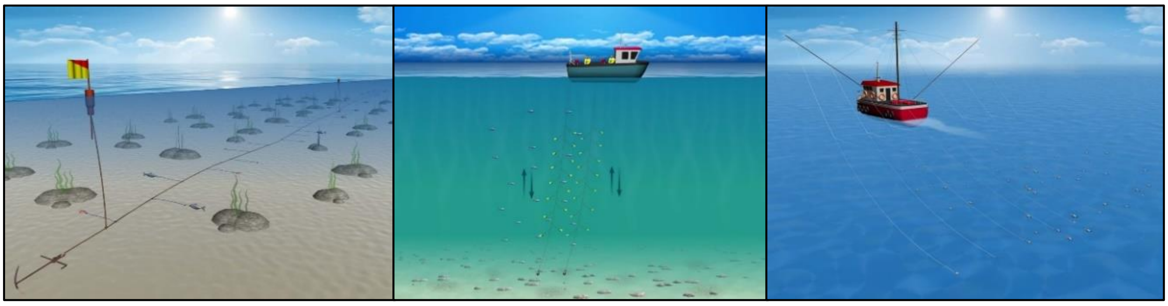

Figure 4. Longlining (left), jigging (middle), trolling (right). © Seafish

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, 2023h).

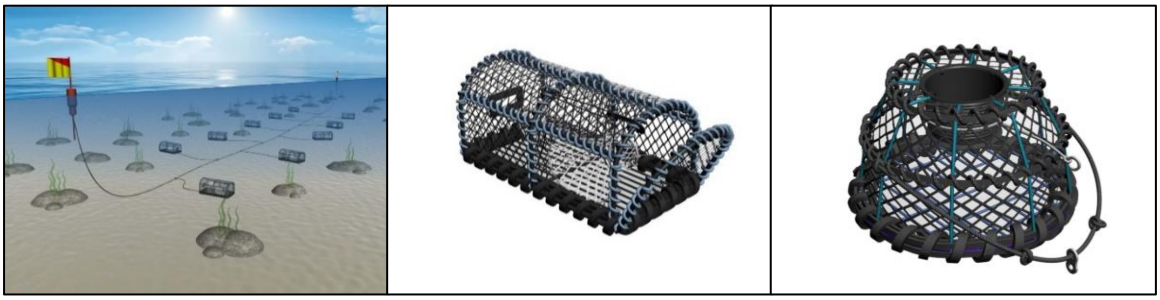

Figure 5. Pots on seabed (left), lobster pot (middle), inkwell pot – brown crab (right). © Seafish

2.5 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 midwater doors to open the net horizontally (Montgomerie, 2022); and
- 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 and is controlled by factors such as the vessel's speed (Montgomerie, 2022). A wide range of vessel sizes are able to utilise these gears, with vessels typically being 10 metres (m) to 40-80 m in length. The largest of these vessels can have the ability to freeze their catch onboard and are capable of removing larger volumes of fish per tow due to their 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 midwater trawls in the UK are blue whiting, anchovy, herring, mackerel and scad (Seafish, 2023g).

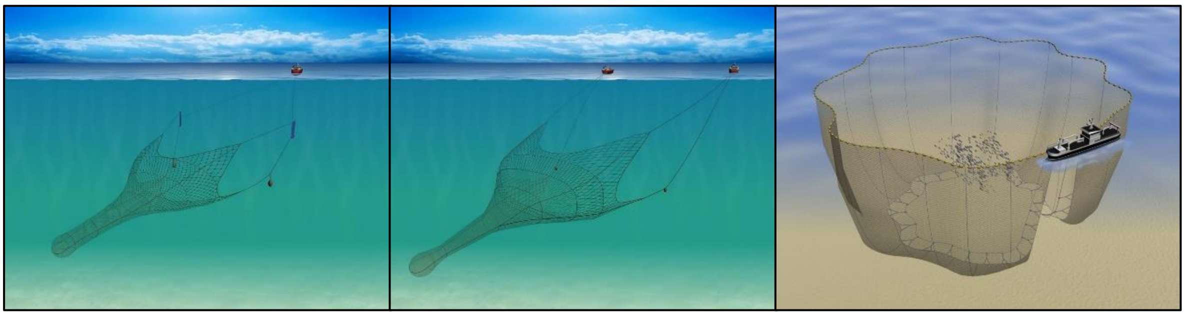

Figure 6. Midwater single trawl (left), midwater pair trawl (middle), purse seine (right). © Seafish

2.6 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 section on general fishing vessel presence.

3 MPA feature: harbour porpoise

Figure 7: Harbour Porpoise © Natural England/Rebecca Walker.

Harbour porpoise (*Phocoena phocoena*) are protected in UK waters through international, European and national legislation. For example, harbour porpoise are listed as an Annex II species under the Conservation of Habitats and Species Regulations 2017 and the Conservation of Offshore Marine Habitats and Species Regulations 2017. Harbour porpoise are a designated feature in six special areas of conservation in UK waters (those within English waters include Bristol Channel Approaches MPA and Southern North Sea MPA).

3.1 Abundance and distribution

Harbour porpoise is a small, toothed whale found in cold temperate to sub-arctic waters in the Northern Hemisphere. Harbour porpoises are the smallest and one of the most abundant cetacean species distributed throughout the UK shelf area (IAMMWG et al., 2015). Harbour porpoise predominantly occur over the continental shelf in water depths shallower than 200 m making seasonal movements to shallower coastal waters between June and September (IAMMWG et al., 2015; JNCC, 2021b).

The number of animals in UK waters is challenging to determine due to their high mobility and seasonal variations in range. A previous estimate of the UK population based on a single survey carried out in July 2005 was approximately 177,000 individuals (Hammond et al., 2013; IAMMWG et al., 2015). The latest estimate based on surveys such as SCANS III (Small Cetacean Abundance in the North Sea) carried out in the summer of 2016 was an abundance of approximately 201,000 individuals (Hammond et al., 2021; IAMMWG, 2022). Hammond et al. (2013) noted that the abundance of animals in 1994 (SCANS I) was similar in 2005 (SCANS II) but there had been a large-scale southerly shift in the North Sea from the northwest to the southwest. Hammond et al. (2021) noted that the distribution of harbour porpoise from the SCANS III survey (2016) and SCANS II (2005) were also similar. However, they highlighted a further movement in the distribution of harbour porpoise, with sightings made throughout the English Channel, suggesting harbour porpoise distribution had expanded from the North Sea and Celtic Sea (at least during the summer months) (Hammond et al., 2021). The reason for this shift is unclear but literature suggests it could be due to changes in prey availability and distribution, environmental variations and/or anthropogenic activities (Hammond et al., 2013; Peschko et al., 2016; Nielsen et al., 2021).

3.2 Life expectancy and reproduction

Studies suggest that the average life expectancy for harbour porpoise is 14 to 15 years with a maximum age of around 24 years old (Lockyer, 1995); although in the UK the average and maximum life expectancy maybe lower at 12 and 20 years respectively (ICES, 2014; Learmonth et al., 2014). Calving and mating is understood to occur between May and August (Lockyer, 1995, 2003; Murphy et al., 2010; Learmonth et al., 2014) with a relatively low survival rate (Lockyer, 1995; Learmonth et al., 2014). Although not fully understood, the reasoning for seasonal movement towards shallower coastal areas may be linked to the feeding of calves as the majority of births are thought to take place during June and July (IAMMWG et al., 2015; JNCC, 2021a). As a long-lived species with a relatively low birth rate, harbour porpoises may be more vulnerable to anthropogenic impacts and have a lower recoverability (Scheidat et al., 2018).

3.3 Prey species

Harbour porpoise use high-frequency echolocation and visual cues to feed on a variety of small demersal and pelagic fish species (Santos and Pierce, 2003; Santos et al., 2004; De Pierrepont et al., 2005; IAMMWG et al., 2015). Their diet is primarily dominated by four key prey guilds ("the big four"): sandeels (Ammodytes sp.), gobies (family Gobiidae), clupeids (herring *Clupea harengus* and sprat *Sprattus sprattus*), and gadoids (whiting *Merlandius merlangus*, cod Gadus morhua and Norway pout *Trisopterus esmarkii*) (Leopold et al., 2015). Porpoise are also known to take a range of other species, such as mackerel (*Scomber scombrus*), horse mackerel (*Trachurus trachurus*), flatfish (such as sole *Solea solea*), cephalopods (Loligo spp.) and crustaceans (*Crangon crangon*); however, these species are generally considered of less importance (Santos and Pierce, 2003; Santos et al., 2004; De Pierrepont et al., 2005; IAMMWG et al., 2015). Although porpoise have a wide diet, Santos and Pierce (2003) suggest that in 'any one area' they will predominantly feed on two to four species. For example, in the North Sea sandeels alongside whiting are likely particularly major components of harbour porpoise diet (Santos et al., 2004; Ransijn et al., 2019). There may be differences in diet between adult and juvenile porpoise, which could, in part, be a result of a lower ability of juveniles to dive (Santos and Pierce, 2003).

3.4 Supporting habitats

Supporting habitats for harbour porpoise (listed in JNCC's AoO as characteristics of the seabed/water column) that are likely to be impacted by these pressures include sandy and coarse sediments. Such sediments cover most of the Southern North Sea MPA and Bristol Channel Approaches MPA (JNCC, 2023b, 2023a); however, other habitat types are also present. JNCC's site selection document for the Southern North Sea MPA notes how defining the supporting habitats for harbour porpoise is challenging due to their highly mobile nature and porpoise distribution being driven by the distribution and availability of prey (JNCC, 2017). However, JNCC note that harbour porpoise show a preference for coarser sediments (such as sand/gravel) rather than fine sediments (such as mud) (JNCC, 2017).

Supporting habitats may have a functional role for harbour porpoise prey species. When assessing the impacts of fishing on the supporting habitats of harbour porpoise, the spawning and nursery grounds of prey species are an important consideration. Impacts to these supporting habitats may cause a loss of foraging sites and reduction in food resources for harbour porpoise.

Spawning areas

Of the harbour porpoise prey items (section 3.3), 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 winter (Macer, 1966; Gould, 1990). Therefore, impacts on spawning grounds of herring and sandeels need to be considered when assessing the potential effects of bottom-contacting fishing gears on the supporting habitats of harbour porpoise.

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, impacts on the nursery areas of sandeels need to be considered when assessing the potential effects of bottom-contacting fishing gears on the supporting habitats of harbour porpoise.

4 Bottom towed gear

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

Direct impacts

- Harbour porpoise bycatch (removal of non-target species).

Indirect impacts

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

4.1 Direct impacts

Direct impacts of bottom towed gear on harbour porpoise include the removal of non-target species (i.e., harbour porpoise bycatch).

4.1.1 Harbour porpoise bycatch (removal of non-target species)

Studies suggest that incidental capture (bycatch) in fishing gear is the most significant human pressure on harbour porpoise (e.g., Baird and Guenther, 1996; Vinther, 1999; Read et al., 2006; Reeves et al., 2013; IAMMWG et al., 2015). However, there is limited evidence available regarding bycatch associated with bottom towed gears and demersal seines (Kaschner, 2003). As found in a literature review published by JNCC in 2015, the most concerning gear type for harbour porpoise bycatch is nets and the limited data available suggests that harbour porpoise bycatch does not occur at a large scale in other fisheries (IAMMWG et al., 2015). However, bottom trawls have been associated with incidental entanglement of small cetaceans (CEC, 2002; Kaschner, 2003) and there have been opportunistic reports of several cetacean species being incidentally caught by bottom and beam trawls (Fertl and Leatherwood, 1997; CEC, 2002). Therefore, harbour porpoise bycatch may arise from bottom towed gears.

Levels of small cetacean bycatch arising from bottom towed fishing gear are generally considered to be low (CEC, 2002). Bottom trawl fisheries have been suggested to take small cetacean bycatch very infrequently (CEC, 2002) and at potentially lower levels relative to midwater trawls (Fertl and Leatherwood, 1997). This is supported by evidence from the UK Bycatch Monitoring Programme, with the latest report (summarising observations from 2019) suggesting that levels of harbour porpoise bycatch from bottom towed gears is minimal (Kingston et al., 2021). No cetacean bycatch was reported from onboard bottom trawls across 552 and 571 monitored days in 2017 and 2018 respectively (Northridge, Kingston and Thomas, 2018, 2019). Similarly, observations from the English and Welsh at-sea Data Collection Framework programmes recorded no marine mammal bycatch onboard bottom trawls in 2017 and 2018 (Northridge, Kingston and Thomas, 2018, 2019). Limited data could be found on levels of harbour porpoise bycatch associated with demersal seines.

The Workshop on estimation of MOrtality of Marine MAmmals due to Bycatch (WKMOMA) produced a report in 2021 that estimated porpoise bycatch by different gear types in harbour porpoise assessment units (ICES, 2021). Assessment units are broadly the equivalent of management units and are the agreed spatial scales under which bycatch assessments are undertaken in the OSPAR (the Convention for the Protection of the Marine Environment of the North-East Atlantic) region. Based on observation data from 2005 to 2021 and a data call for multiple countries with fisheries operating in the OSPAR region (ICES, 2021), the total number of harbour porpoise bycaught was estimated for single and twin bottom otter trawls. Generally, these bottom towed gears resulted in bycatch at levels that were relatively low compared to total bycatch across the assessment unit (Table 1). In the Irish Sea, however, bottom towed gears accounted for approximately 10 of the 12-harbour porpoise estimated to be bycaught across all gear types (Table 1).

Table 1 Annual bycatch estimates for bottom towed gears and all gears by assessment unit. Data is sourced from the Workshop on estimation of MOrtality of Marine MAmmals due to Bycatch (WKMOMA) report (ICES, 2021). Bycatch estimates are rounded to the nearest integer and 95% confidence intervals are shown in parentheses. Two bycatch estimates are provided for the North Sea: a higher estimate (includes data from one country with very frequent bycatch observations from preferential sampling of targeted vessels) and a lower estimate (with data from this country removed). Estimates are shown for all gears and individual metiers: GNS/GND (set gillnets (anchored) / drift gill nets), GTR (trammel nets) and OTB / OTT gears (single boat bottom otter trawls and twin bottom otter trawls). OSPAR bycatch thresholds are shown per assessment unit and are based on enabling the population to recover or be maintained at 80% carrying capacity, with 80% probability within a 100-year period.

Assessment unit	Métier	Bycatch estimate (number of animals)	Bycatch threshold
North Sea	All gears	5,929 (3,176 – 10,739) 1,627 (922 – 3,325)	1,662 animals
	OTB / OTT	123 (54 – 281) 123 (54 – 281)	
	GNS/GND	5,327 (2,845 – 9,637) 1,306 (747 – 2,698)	
	GTR	479 (277 – 821) 198 (120 – 346)	
Celtic Sea	All gears	738 (284 – 2,240)	43 animals
	OTB / OTT	108 (47 – 244)	

	GNS/GND	374 (152 – 1,079)	
	GTR	257 (85 – 917)	
Irish Sea	All gears	12 (6 – 27)	34 animals
	OTB / OTT	10 (5 – 24)	
	GNS/GND	2 (1 – 3)	
West Scotland	All gears	305 (134 – 686)	78 animals
	OTB / OTT	50 (22 – 113)	
	GNS	255 (112 – 572)	

Further, evidence from outside UK waters also suggests that, although harbour porpoise may be caught in bottom trawls, the number of bycaught individuals is likely to be low. From 2016 to 2018, one harbour porpoise was observed (across 115 days at sea) as bycatch in bottom otter trawls in the Bay of Biscay and, similarly, one harbour porpoise was bycaught (across 2,820 observed days at sea) in bottom otters trawls in the Celtic Sea (ICES, 2020b). From 1996 to 2000, no incidental catches of cetaceans were reported from approximately 1,500 hauls monitored in the Basque bottom trawl fishery (CEC, 2002). Spanish observer programmes also found no incidents of harbour porpoise bycatch from bottom trawls, covering approximately 480 hauls observed in ICES areas VIIIc in 1997 and 760 hauls in 1999 to 2000 (CEC, 2002). Rates of harbour porpoise bycatch associated with bottom towed gear may also be low in the northwest Atlantic (Lyssikatos, 2015; Chavez-Rosales et al., 2018).

Evidence classifying the risk posed by different fishing gears for harbour porpoise bycatch indicates that bottom towed gears and demersal seines likely pose a low risk. Expert participants of the ICES Working Group on Bycatch of Protected Species (WGBYC) in 2019 classed bottom trawls (including dredges, bottom otter trawls, multi-rig otter trawls, bottom pair trawls and beam trawls) and seines (including anchored seines, pair seines and fly shooting seines) as having low risk for harbour porpoise bycatch (ICES, 2019). Similarly, through Productivity Susceptibility Analysis, Brown et al. (2013) estimated that harbour porpoise have a low-risk score for bycatch from bottom trawls and seines in Irish waters based on porpoise productivity, susceptibility and the spatial overlap between harbour porpoise distribution and fishing effort (Brown et al., 2013). The draft UK Dolphin and Porpoise Conservation Strategy (UKDPCS) assessed harbour porpoise as having medium vulnerability to bycatch from trawls and purse seines in UK water due to high sensitivity of individual animals and medium exposure to the pressure (The Scottish Government, 2021). However, the UKDPCS does not differentiate between midwater and bottom trawling, so such scores are not specific to bottom towed gear. The UKDPCS recommends that current measures are considered adequate for the bycatch pressure exerted by trawls on harbour porpoise in UK waters, but further research is recommended.

4.2 Indirect impacts

Indirect impacts of bottom towed gear on harbour porpoise include the removal of target and non-target prey species and physical loss, change or damage to supporting habitats.

4.2.1 Removal of target and non-target prey species

All fishing gears remove 'target' species and can also remove 'non-target' species (bycatch). The species caught by bottom towed gears (for example, demersal fish) could overlap with the prey species of harbour porpoise (section 3.3), meaning there is potential competition for resources (Santos and Pierce, 2003; IAMMWG et al., 2015; Wisniewska et al., 2018). Bottom towed gears by design target species living on, in or close to the seafloor (demersal species). The target species will vary depending on the type of gear being used and geographic location (see section 2.1). There is limited literature investigating how fishing effort by bottom towed gear may impact prey availability and harbour porpoise diet; consequently, a more generalised review has been completed.

IAMMWG et al. (2015) describe harbour porpoise as opportunistic feeders that may change their diet and range in order to reach preferable feeding grounds or species. Stomach analysis studies show that the types and sizes of prey consumed by harbour porpoise likely depends on prey abundance and availability, which in turn could be linked to a range of biological and/or physical variables (Santos and Pierce, 2003; Santos et al., 2004; Sveegaard. et al., 2012; Andreasen et al., 2017; Wisniewska et al., 2018). These studies also suggest that prey preference could vary geographically, seasonally and interannually, and could also depend on the age, size and sex of harbour porpoise (Santos and Pierce, 2003; Andreasen et al., 2017; Hoekendijk et al., 2018; Wisniewska et al., 2018). Literature also suggests that harbour porpoise require high daily consumption rates to meet their high energetic requirements, which are a result of their small size, high metabolic rates, heat loss and life cycle; with energetic benefits of prey depending on the prey type and volume consumed (Santos and Pierce, 2003; Lockyer, 2007; Hoekendijk et al., 2018; Wisniewska, Johnson, Teilmann, Siebert, et al., 2018).

Harbour porpoise feed on a wide variety of fish species (section 3.3), some of which, for example sandeels, do overlap with the species targeted by some bottom towed gear types. However, a review of the literature suggests that harbour porpoise will generally take smaller fishes than those targeted by the fishing industry, meaning there may be little overlap for commercially targeted fish and potentially less competition for resources (Santos and Pierce, 2003; Hoekendijk et al., 2018; Wisniewska et al., 2016, 2018). For example, Hoekendijk et al. (2018) note that from review of studies using stomach analysis, harbour porpoise do not tend to consume fish of ≥ 30 centimetres (cm), which is generally considered commercial size (albeit with exceptions, such as herring and mackerel, i.e., ‘pelagic’ species). Andreasen et al. (2017) report a range in prey sizes from 2.5 cm to 63 cm for harbour porpoise in the Baltic Sea. Hoekendijk et al. (2018) note that in the North Sea juvenile harbour porpoise feed mainly on small lean fish (under 10 cm) such as gobies, with the diet of adults consisting of larger and more energy rich prey such as gadoids, whiting and sandeels, which range from 10 cm to 30 cm (Hoekendijk et al., 2018). The minimum landing size for sandeels is 20 cm (MMO, 2018), and thus there may be overlap between sandeels targeted by commercial fisheries and those taken by porpoise. Smaller sizes (3 to 10 cm) of consumed prey were reported by Wisniewska et al. (2016) and while Hoekendijk et al. (2018) argued that the study may not be representative for the population due to survey design (e.g. the study held porpoise prior to release), both authors agree that the overlap with the commercial size of fish species is limited (with the exception of pelagic species mentioned above) (Hoekendijk et al., 2018; Wisniewska et al., 2016, 2018). The study by Wisniewska et al. (2016) was based on four juveniles and one adult and as discussed earlier, the size of prey that can be consumed by juveniles maybe limited by factors such as the animal’s size. Wisniewska et al., 2018 state that harbour porpoise aged two years and younger make up a significant proportion of the population so argue that their results are still relevant to investigating the overlap between harbour porpoise diet and commercial fisheries. Overall, the evidence reviewed suggests that bottom towed (demersal) fisheries may be less in competition with harbour porpoise for prey compared to pelagic fisheries and porpoise may not be dependent on fish of commercial size (Lockyer and Kinze, 2003; Leopold, 2015; Andreasen et al., 2017; Hoekendijk, J., Spitz, J., Read, A.J., Leopold, M.F. and Fontaine, 2018). However, there could still be an overlap (and thus potential competition) between fish targeted by bottom towed gear fisheries and those targeted by porpoise (especially for sandeels) and consideration of bottom towed gear impacts on larger fish and subsequent impacts on reproductive output are also required.

Montgomerie (2022) describes how mesh size and gear material varies for different bottom towed gears and their target fisheries. Legislation currently in place controls mesh sizes with the aim of improving gear selectivity, with Montgomerie (2022) noting that in the UK there is a trend for using larger mesh sizes than legislative requirements to further increase gear selectivity. This may allow the smaller fish to escape from the gear, remaining available for harbour porpoise, reducing competition for this size of resource.

Although various measures, such as mesh sizes, are in place to reduce the catch of fish not a targeted by commercial fisheries (Pierce et al., 2022), bottom towed gear may also impact the prey availability of porpoise through the incidental removal of non-target fish species. Modelling based on beam and otter trawl surveys in the North Sea has shown that non-target fish species may have levels of fishing mortality that are at least as high, if not higher, than those of targeted fish species (Piet et al., 2009). Consequently, the mortality of non-target species by bottom towed fishing gear could impact porpoise through direct removal of prey (assuming there is overlap between non-target species and prey) or indirectly, by impacting wider trophic dynamics (Bellido et al., 2011).

Further to the initial short-term impacts on prey species, there are the longer-term indirect impacts on harbour porpoise from fishing, related to prey availability and distribution (Reijnders, 1992; Pinnegar et al., 2002; Daskalov et al., 2017; Durante et al., 2022). As described by Durante et al. (2022), fishing can lead to shifts in trophic structure due to overfishing of species at higher levels in the food web. A change in trophic levels may result in reduced biodiversity and changes in resident fish species shifting benthic communities towards more short-lived and smaller species (Pauly and Palomares, 2001; Pinnegar et al., 2002). Ultimately this may cause harbour porpoise to change foraging behaviour (for example changing feeding grounds or switching prey from preferred species to lower calorific smaller fish), which in turn may affect porpoise distribution and/or potentially negatively affect the short- or long-term health of porpoise (e.g., Santos and Pierce, 2003; IAMMWG et al., 2015; Spitz et al., 2018; Booth, 2020; Pierce et al., 2022). The draft UKDPCS note that starvation is recorded as a common cause of death in individuals found stranded but there is no understanding of its cause in the population; potentially, competition for resources and wider trophic changes could be a contributing factor (Wisniewska et al., 2018; The Scottish Government, 2021).

Overall, it is challenging to understand the magnitude of impacts to harbour porpoise from bottom towed gears through removal of prey species. The literature suggests that there are other gears and pressures (such as gillnetting and bycatch) that present a greater risk of impacting harbour porpoise (Hoekendijk et al., 2018). Obtaining direct evidence of adverse impacts of resource depletion on cetacean populations is challenging (Pierce et al., 2022). Multiple factors, such as climate change and other forms of both anthropogenic and natural environmental change, may act in-combination to affect prey distribution and abundance (Santos and Pierce, 2003; IAMMWG et al., 2015; Pierce et al., 2022). Although fishing extraction from bottom towed gears could negatively impact porpoise through effects on the distribution, abundance, biomass or quality of prey, such prey depletion may be localised and not necessarily be associated with overfishing (DeMaster et al., 2001; Lassalle et al., 2012; Pierce et al., 2022). Therefore, a local and/or regional review would appear to be needed that takes levels of fishing, type of fishing, prey preferences and area specific characteristics into account.

4.2.2 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 (Stage 3 Fishing Gear MPA Impacts Evidence Bottom Towed Gear document[3]). Supporting habitats for harbour porpoise (described in section 3.4) that may be impacted by bottom towed gear pressures include sandy and coarse sediments. Section 3.4 includes information about supporting habitats requiring consideration based on the spawning and nursery areas for relevant prey items. In areas offshore of 6 nm, impacts to herring and sandeel spawning grounds and sandeel nursery grounds may have particular implications for harbour porpoise (section 3.4).

Although harbour porpoise are generalist foragers, preying on a range of demersal and pelagic species, in any one area porpoise likely focus on a few key species (section 3.3). In the North Sea, sandeels are an especially important component of harbour porpoise diet (section 3.3). Consequently, impacts from bottom towed-towed gear on the spawning and nursery grounds of sandeels is of particular concern for harbour porpoise in the North Sea.

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 sandy and coarse sediment habitats via abrasion and penetration pressures.

The full impacts to harbour porpoise from pressures impacting supporting habitats (and associated species) are difficult to identify due to the complexity of the interactions and limited evidence. Advice from JNCC suggests that given the habitats present with the two porpoise MPAs (in MMO jurisdiction) are sedimentary habitats, physical loss of habitat is unlikely (JNCC pers. comms, 2022). However, impacts may occur through physical modification of foraging areas, in particular damage to spawning and nursery grounds of prey, and consequently a potential reduction in food resources. However, as noted by the draft UKDPCS (The Scottish Government, 2021), there are limited studies on the effects of these pressures on harbour porpoise. The effects to harbour porpoise will depend on the level of exposure (for example the greater the level of fishing activity 'exposure' the greater the vulnerability of harbour porpoise). Therefore, areas with a greater concentration of bottom towed fishing may present a higher risk, particularly when overlapping spatially with herring and sandeel spawning grounds and sandeel nursery grounds as well as with other industries, such as aggregate extraction (The Scottish Government, 2021). As such, effects may be more significant on a local scale and 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 harbour porpoise MPAs in consideration, this may contribute to the protection of supporting habitat for harbour porpoise in certain areas.

4.3 Summary of the effects of bottom towed gear on harbour porpoise

Bottom towed gears have the potential to impact harbour porpoise. As such, site level assessments are required to determine whether management may be needed for MPAs protecting harbour porpoise. The pressures of most concern that need to be assessed further in site level assessments are:

- bycatch;
- removal of target and non-target prey species;
- physical loss or damage to supporting habitats (and/or associated species).

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.

5 Nets (gillnets)

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

Direct impacts

- Harbour porpoise bycatch (removal of non-target species);
- Underwater noise from acoustic deterrent devices (ADDs).

Indirect impacts

- Removal or target and non-target prey species;
- Physical loss, change or damage to supporting habitat.

5.1 Direct impacts

Direct impacts of nets on harbour porpoise include the removal of non-target species (i.e., harbour porpoise bycatch). For this review the evidence for nets has been divided up into sub-sections to allow the consideration of more specific evidence. As defined in section 2.2, this review uses ‘gillnet’ as a collective term for static gear that uses gilling or entangling meshes to trap fish. Evidence for general gillnets is first summarised, and then where available, evidence on the direct impacts of specific styles of gillnets (drift nets, tangle nets and trammel nets) are summarised.

5.1.1 Harbour porpoise bycatch (removal of non-target species)

Gillnets

Anchored nets, particularly gillnets, are considered to be the greatest concern for harbour porpoise bycatch in European and UK waters, including in the North Sea, English Channel and Celtic Sea, and could potentially be leading to levels of bycatch that are unsustainable in the longer term (CEC, 2002; Read et al., 2006; Anton et al., 2010; Brown et al., 2013; IAMMWG et al., 2015; Calderan and Leaper, 2019; Kingston et al., 2021).

Geographically, most of the estimated harbour porpoise bycatch in UK net fisheries occurs in the English Channel and Celtic Sea (ICES areas 7d-g) and the Southern North Sea (ICES area 4c) (Northridge et al., 2018, 2019; Kingston et al., 2021). Bottom-set gillnets pose a particularly long-known challenge for cetacean bycatch off the southwest coast (Tregenza et al., 1997), where some of the highest numbers of harbour porpoise bycatch in the UK have been reported (Northridge et al., 2018, 2019; Kingston et al., 2021). Clean Catch UK (a collaborative programme bringing together scientists, industry and government organisations to reduce wildlife bycatch by commercial fishing) has a Cetacean Local Focus Group based in Cornwall, where work is on-going to monitor and develop methods to reduced cetacean bycatch (Clean Catch UK, 2023). This includes the Cetacean Bycatch Mitigation Study, which is investigating whether ADDs and/or lights reduce dolphin and harbour porpoise bycatch in the inshore net fishery (Clean Catch UK, 2022). With high overlap between harbour porpoise distribution and gillnets (Calderan and Leaper, 2019), the eastern English Channel and southern North Sea are also areas of concern. In the North Sea, bottom-set gill net fisheries may cause the majority of all fisheries-related mortalities to cetaceans (Vinther, 1999; Kaschner, 2003). Assuming there are no seasonal spatial delineations, approximately 9% of total bycatch in the UK gillnet fleet may occur within harbour porpoise MPA regions, with potentially between 16 and 39 porpoise bycaught per year in the Southern North Sea MPA and between 40 and 80 porpoise bycaught in Bristol Channel Approaches MPA (Coram and Northridge, 2018).

Harbour porpoise bycatch in gillnets is also a concern outside of the UK waters (ICES, 2021), with foraging habitats and gill net fisheries overlapping both in the UK and abroad (Coram and Northridge, 2018; Calderan and Leaper, 2019; Ransijn et al., 2019; Maeda et al., 2021). Analysing data from across the North Sea and Celtic Sea, the ICES WGBYC found that, since 2005 the highest bycatch rates of harbour porpoise were from gillnet fisheries (ICES, 2020b). Similarly, the WKMOMA report found that gillnet metiers consistently accounted for the majority of porpoise bycatch estimated to occur annually in the North Sea, Celtic Sea, Irish Sea and West Scotland assessment units (Table 1; ICES, 2021).

Evidence classifying the risk posed by different fishing gears for harbour porpoise bycatch indicates that bycatch from gillnets pose a relatively high risk of impacting porpoise populations. Expert participants of the ICES WGBYC in 2019 classified nets (trammel nets, set gillnets and drift nets) as having a high risk of negative impacts on porpoise populations (ICES, 2019). Similarly, through Productivity Susceptibility Analysis, Brown et al. (2013) estimated harbour porpoise in Irish waters to have a high-risk score for bycatch from gillnets relative to other gear types based on their productivity, susceptibility and the spatial overlap between harbour porpoise and fishing effort (Brown et al., 2013). The draft UKDPCS assessed harbour porpoise as having medium vulnerability to bycatch from set (fixed) nets (stemming from high sensitivity and high exposure) with high confidence, and medium vulnerability also to drift net fishing (stemming from high vulnerability and low exposure) with medium confidence (The Scottish Government, 2021). However, the evidence section of the UKDPCS does highlight that bycatch is greatest in set nets (The Scottish Government, 2021). Although the bycatch varies by region - with the southwest being of the greatest concern, followed potentially by the North Sea – bottom-set nets are recognised as the greatest anthropogenic pressure for harbour porpoise in UK waters (The Scottish Government, 2021).

Drift nets

Harbour porpoise bycatch has been observed in bottom drift nets (targeting demersal species) and surface and midwater drift nets (targeting small pelagic species) (Kingston et al., 2021). The UK has several small drift net fisheries; however, harbour porpoise bycatch is not likely to occur on a large scale in these fisheries compared to other gillnet fisheries (CEC, 2002; IAMMWG et al., 2015).

This is supported by data from the UK Bycatch Monitoring Programme, which shows that drift nets have relatively low estimates of harbour porpoise bycatch relative to other gill net types (Northridge et al., 2018, 2019; Kingston et al., 2021). In 2019, the total number of harbour porpoise bycaught was estimated to be approximately 14 individuals (95% confidence limit, CL: 2 – 48) in UK bottom drift nets and 18 individuals (95% CL: 4 - 52) in UK midwater drift nets (Kingston et al., 2021). Using these point estimates, drift nets accounted for approximately 4% of the total number of harbour porpoise bycaught in UK net fisheries in 2019 (Kingston et al., 2021). Drift nets may have similar bycatch rates (i.e., number of animals caught per haul) as other gillnet fisheries (Northridge et al., 2019). Consequently, the low estimates of porpoise bycatch from drift nets in UK waters relative to other net types, could be due to these fisheries occurring at a smaller-scale (as opposed to drift nets having lower bycatch rates).

Tangle and trammel nets

Tangle and trammel nets may significantly contribute to total harbour porpoise bycatch in UK waters (STECF, 2019). In UK waters in 2019, tangle/trammel nets are estimated to have resulted in an annual bycatch of 376 (95% CL: 306 – 505) harbour porpoise (assuming full ADD compliance), accounting for approximately 45% of all harbour porpoise estimated to be bycaught in UK net fisheries (Kingston et al., 2021). From 2010 to 2018, 67 harbour porpoise were caught during approximately 3,600 hauls observed onboard UK tangle/trammel net vessels (without ADDs), giving a mean annual bycatch rate of 0.019 animals per haul (Northridge et al., 2019). The UK Bycatch Monitoring Programme found that - out of seven net metiers - tangle/trammel nets were the largest contributor to harbour porpoise bycatch from

2017 to 2019, accounting for approximately 41 to 45% of all harbour porpoise bycatch (assuming no ADD) from UK net fisheries (Northridge et al., 2018, 2019; Kingston et al., 2021).

Population-level impacts of nets via bycatch

Assessments investigating whether bycatch from net fisheries significantly impact harbour porpoise populations require knowledge of 1) the abundance of harbour porpoise; 2) the estimated total bycatch mortality associated with the fishery; and 3) a reference point or criterion to determine if total bycatch mortality has significant effects. These assessments are typically undertaken at large spatial scales, such as for assessment units.

The OSPAR Quality Status Report (QSR) 2023 provides the most current assessment of harbour porpoise bycatch in the north-east Atlantic (Taylor et al., 2022). This assessment uses a criterion (or threshold) based on the number of porpoise bycaught that would enable the population to recover to, or be maintained at, 80% of carrying capacity (the maximum number of individuals an area can sustain), with 80% probability, within a 100-year period (Taylor et al., 2022). For all assessment units overlapping UK waters (i.e., the Greater North Sea, the Celtic and Irish Sea, and West Scotland and Ireland assessment units) the total bycatch mortality in 2020 was estimated to be over the equivalent threshold values (Taylor et al., 2022). However, these estimates are for all gear types, and thus does not solely focus on nets.

The WKMOMA 2021 report estimated porpoise bycatch in harbour porpoise assessment units specifically from gillnet metiers and also provided criterion for whether bycatch mortality may have an impact at a population level (Table 1). For the North Sea, Celtic Sea and West Scotland assessment units, estimated total bycatch from gillnet metiers in 2020 exceeded the equivalent thresholds (Table 1). For the Irish Sea assessment unit, bycatch from gillnets did not exceed the threshold; however, this threshold was exceeded if the Celtic and Irish Sea assessment units were combined (ICES, 2021).

The UK Marine Online Assessment Tool used different criterion for assessing whether bycatch from static nets had population level effects (Mitchell et al., 2018). This assessment was based on thresholds from ASCOBANS: that total bycatch mortality should not exceed 1.7% of the best available estimate of the population, and ideally bycatch rates should be below 1% (Mitchell et al., 2018). In contrast to the OSPAR Quality Status Report 2023 and the WKMOMA report, total estimated bycatch from static nets (trammel nets, set gillnet and driftnets) in 2013 was below the precautionary threshold of 1% of the best population estimate in the North Sea assessment unit in 2013. This is consistent with other assessments for North Sea where bycatch from nets was estimated to be approximately 0.5% of the population size; thus, below both the 1.7% and 1% criterion (Hammond et al., 2019). The UK Marine Online Assessment Tool was, however, inconclusive in the Celtic Seas assessment unit because bycatch in 2013 was estimated to be below the threshold of 1.7% of the best population estimate, but above the precautionary threshold of 1% (Mitchell et al., 2018). This is consistent with a report by ICES WGBYC, which - based on data from 2017 found that harbour porpoise bycatch in the Celtic Sea may exceed the 1% (but not the 1.7%) threshold (ICES, 2018).

Overall, the most-recent assessments of bycatch (such as the WKMOMA 2021 report) suggest that total bycatch mortality from nets may exceed thresholds at which populations may be negatively impacted. However, such results can contrast with prior reports and are at the large spatial scales of assessment units. Determining precise population-level effects of bycatch from net fisheries on harbour porpoise remains challenging (IAMMWG et al., 2015; ICES, 2019). Further analysis of evidence sources at different spatial scales will be required to fully consider the impact of bycatch from nets when delivering site level assessments.

5.1.2 Underwater noise (ADDs)

Anthropogenic underwater noise from nets may be associated with ADDs (also known as pingers), which are required in UK waters. ADDs are legally required for bottom set gill nets and entangling nets for vessels of 12 m or over (Table 2). In 2018, 24 UK vessels (over 12 m) fished in areas requiring the use of ADDs (Carlén and Evans, 2020). Following 10 inspections in English and Welsh waters in 2018, one vessel was found to have no ADDs onboard (Carlén and Evans, 2020). In 2019, the UK Bycatch Monitoring Programme found that 95% (74 out of 78) of monitored hauls had ADDs attached as required (Kingston et al., 2021). This evidence suggests that there are a limited number of vessels required to use ADDs in UK waters and compliance is generally high.

Table 2: Use of ADDs required under Regulation (EU) 2019/124[4] for any bottom set gillnet or entangling net for vessels of 12 m or more, including area, gear and time of year when ADDs are required.

ICES area and gear	Time of year
Area IV and the mesh size is 220 mm or more	All-year
Area IV and the net is of any mesh size and is total length is 400 m or less	All-year
Area VII d, e, f, g, h and j	All-year

Although ADDs are effective at reducing bycatch mortality of harbour porpoise (STECF, 2019; Carlén and Evans, 2020; Kingston et al., 2021), these devices may also have negative effects on the species they were designed to protect. Seal deterrent devices used on aquaculture nets can lead to physical trauma in harbour

[4] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32019R1241

porpoise through auditory impairment (Findlay et al., 2021). However, such devices are generally higher powered than those used on gillnets; thus, physical injury is unlikely to be caused by gillnet ADDs (IAMMWG et al., 2015).

The most likely negative impacts on harbour porpoise from ADDs on gillnets are behaviourally-mediated effects (Boyd, 2008). Foraging disturbance and habitat displacement are considered the main negative behavioural impacts of ADDs on harbour porpoise (Carlén and Evans, 2020). ADDs produce sounds that cause individuals to undertake aversive behaviour, which displaces the animal from the vicinity of the ADD (and in-turn reduces bycatch) but may also lead to interrupted foraging behaviour and habitat displacement (Dawson et al., 2013). Mandatory use of ADDs on gillnets for vessels of all sizes could reduce harbour porpoise bycatch within porpoise MPAs in UK waters by approximately 60 to 90%, but could also result in animals being excluded from potentially 0.001 to 1.18% of these MPAs (Coram and Northridge, 2018).

Studies in European waters also suggest that ADDs could lead to habitat displacement (van Beest et al., 2017). For example, one study suggests that harbour porpoise may be displaced by less than 2.5 kilometres (km) or more than 5 km from ADDs (Kyhn et al., 2015). A study in the Baltic Sea (as well as round Vancouver Island, Canada) found that harbour porpoise avoided areas within audible range (130 to 1,140 m) of ADDs on gillnets, which could lead to harbour porpoise feeding in sub-optimal areas (Culik et al., 2001).

With high metabolic demands (Wisniewska et al., 2016), harbour porpoise may be particularly vulnerable to exclusion from foraging in high-quality habitat (van Beest et al., 2017). Prolonged disruptions in energy acquisition could adversely affect individual fitness and ultimately population size (van Beest et al., 2017). A combination of time-area closures with ADDs may have the overall largest positive effects: reducing bycatch and minimising behavioural impacts (van Beest et al., 2017).

In contrast, other studies indicate that ADDs may not lead to significant habitat displacement. Analysing the impacts of Banana Pingers (Fishtek Marine Limited) on harbour porpoise in Cornwall in 2012 and 2013, Omeyer et al. (2020), found that ADDs had very localised effects as displacement was mostly within 100 m. ADDs also did not lead to long-term harbour porpoise displacement, with porpoise returning to the ensonified area after the pinger was turned off with no delay (Omeyer et al., 2020). A review by Dawson et al. (2013) suggests that ADDs are likely to cause displacement on smaller spatial scales, but because individual harbour porpoise generally have large home ranges and use a variety of habitats, this displacement is unlikely to have population-level effects.

In summary, the negative impacts of gillnet ADDs on harbour porpoise are likely to be through behaviourally-mediated effects; however, the scale of these impacts is unclear. Displacement impacts will likely depend on the spatial scale over which

ADDs are used, alongside the type of ADD alarm (Culik et al., 2001). Further work is required to understand whether wide-spread ADD use would have significant impacts for harbour porpoise populations (IAMMWG et al., 2015).

5.2 Indirect impacts

Indirect impacts of nets on harbour porpoise include the removal of target and non-target prey species and physical loss, change or damage to supporting habitats.

5.2.1 Removal of target and non-target prey species

No evidence was found investigating how fishing effort by nets may impact prey availability and harbour porpoise diet (with the majority of studies for nets focusing on net bycatch); as such, a more general review has been conducted.

As described in section 3.3, harbour porpoise feed predominantly on demersal and pelagic fish alongside a variety of other species. Consequently, there is the potential for overlap between porpoise prey and the various pelagic and demersal species targeted by nets (section 2.2). For example, single-walled gillnets and trammel nets in the UK mainly target cod, which belongs to the gadoid family (one of the ‘big four” prey guilds targeted by porpoise), whilst inshore drift nets mainly target herring, which belongs to the clupeids (again one of the “big four”) (section 2.2 and 3.3). If nets were to contribute to declines in a specific common prey, then this could lead to increased competition and porpoise having to switch to a different and potentially less preferential prey type (Santos and Pierce, 2003). However, as gillnet mesh sizes and slack will be rigged to specific target species (section 2.2), any such competition for resources will be fishery-specific.

The potential impacts of prey removal from net fisheries on porpoise will also be area- and species-specific. As discussed in section 3.3, harbour porpoise diet will vary with area, for example, porpoise in the North Sea having particular reliance on sandeels and whiting (Santos and Pierce, 2003; Ransijn et al., 2019). These species are generally targeted by bottom-towed and midwater-towed gears respectively and thus competition between porpoise and net fisheries in the North Sea may be more limited. Furthermore, as discussed in section 4.2.1, porpoise tend to take animals under 30 cm (section 4.2.1). Therefore, for net fisheries targeting species such as cod, where minimum conservation reference size is 35 cm (MMO, 2018), there may be less direct competition with porpoise.

The removal of prey species by nets could have potentially greater impacts on porpoise during the summer months. As shown from maps of fishing effort data, set gillnet and drift nets tend to operate in the inshore areas of UK waters (Global Fishing Watch, 2023); whilst harbour porpoise may move further inshore during June to September, possibly due to calving (IAMMWG et al., 2015; JNCC, 2021). Therefore, there may be increased competition between harbour porpoise and net fisheries for resources and space in inshore areas in the summer months.

It is unclear whether harbour porpoise are attracted to nets as a potential food source or whether they just happen to forage near to gillnets (Boström et al., 2013; Maeda et al., 2021; Macaulay et al., 2022).(Maguire et al., 2002) Natural England have advised that it is unlikely for cetaceans in general to consume dead prey, but some species tend to feed on disorientated prey around nets (Natural England pers. comms., 2022). In relation to nets and as discussed in section 5.1.2, ADDs are used with the aim of deterring cetaceans (Montgomerie, 2022) and are effective at deterring porpoise and reducing bycatch.

Bycatch from single-walled gillnets, tangle nets and trammel nets my include any demersal species (Seafish, 2023c, 2023j, 2023k). Therefore, there is the potential for nets to impact harbour porpoise by removal of non-target (bycaught) fish species. All gillnets are, however, fairly size selective, as the mesh size will regulate what size range of fish will be caught (Seafish, 2023c). Furthermore, gillnets may also be species selective as decisions can be made on the area nets are shot in to increase the abundance of target fish species being caught (Seafish, 2023c). This suggests that net fisheries could be unlikely to have significant impacts on prey availability for harbour porpoise through removal of non-target fish species, although potential impacts cannot be ruled out.

While literature suggests that there is some overlap between net target species and harbour porpoise prey (meaning competition for prey species), it is highly challenging to differentiate the impacts of prey removal from netting activities from the cumulative impacts of multiple other factors that may also reduce prey availability or alter prey distribution (such as removal of prey by non-netting fisheries and climate change). The volume of fish removed from netting activities in the UK is lower than other fishing gears such as trawls (MMO, 2023), and bycatch of fish species may be limited by regulating mesh size and where nets are shot (Seafish, 2023c). Consequently, the risk to fish stocks and therefore prey availability through removal of target and non-target prey species by net fisheries should be comparatively low. However, as the main prey species of harbour porpoise varies, including by geographical location, a more localised assessment may be beneficial. Monitoring prey removal pressures from fishing activities with the change in other contributing factors at a local level (as part of a site level assessment) may be required due to the variation in impacts and to take account of site specifics (such as characteristics and fishing level activity).

5.2.2 Physical loss, change or damage to supporting habitat

Anchored nets may cause physical loss, change or damage to supporting habitats through abrasion, disturbance and penetration of seabed and subsurface substrates (Stage 3 Fishing Gear MPA Impacts Evidence Anchored Nets and Lines document[3]).

Information on supporting habitats for harbour porpoise is provided in section 3. Habitats which may be impacted by pressures from anchored nets are sand, mud and mixed sediment habitats. The specific pathways through which anchored nets 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[3].

Understanding the impact to harbour porpoise from nets interacting with supporting habitats is challenging due to the complexity of variables involved and the limited evidence available. However, there is a potential pathway for nets (mainly anchored nets) to disturb sand, mud and mixed sediment habitats, particularly at high levels of fishing intensity (Hall et al., 2008). This may occur on a scale that could have a significant impact on prey species. The effects to harbour porpoise will depend on the level of exposure: areas with a greater concentration of fishing activity will present a higher risk, particularly when overlapping spatially with other industries, leading to in-combination effects (The Scottish Government, 2021).

Overall, the interaction of nets with the seabed is likely to be minimal, and due to their nature, any impact to harbour porpoise is expected to be low; therefore, a significant impact is not expected. However, site level assessments are required to consider the local characteristics, activity levels and operations.

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 harbour porpoise MPAs in consideration, this may contribute to the protection of harbour porpoise supporting habitat in certain areas.

5.3 Summary of the effects of nets on harbour porpoise

Nets have the potential to impact harbour porpoise. As such, site level assessments are required to determine whether management may be needed for MPAs protecting harbour porpoise. The pressures of most concern that need to be assessed further in site level assessments are:

- bycatch;
- removal of target and non-target prey species.

Given the potential to negatively impact harbour porpoise populations (section 5.1.1), MMO consider bycatch from nets to be a particularly important pressure, which will need detailed assessment. 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.

6 Lines

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

Direct impacts

- Harbour porpoise bycatch (removal of non-target species).

Indirect impacts

- Removal or target and non-target prey species;
- Physical loss, change or damage to supporting habitat.

6.1 Direct impacts

Direct impacts of lines on harbour porpoise include the removal of non-target species (i.e., harbour porpoise bycatch).

6.1.1 Harbour porpoise bycatch (removal of non-target species)

Limited evidence is available regarding bycatch associated with line gears, such as longlines (ICES, 2020a). As found in a literature review by IAMMWG et al. (2015), the most concerning gear types are nets and the limited data available suggests that harbour porpoise bycatch does not occur at a large scale in other fisheries. However, some limited data is available on bycatch of harbour porpoise in line fisheries in the UK and further afield.

Evidence from the UK Bycatch Monitoring Programme indicates that line fisheries are associated with low levels of harbour porpoise bycatch (e.g., Kingston et al., 2021). No harbour porpoise bycatch was observed from handlines in 2017, 2018 and 2019 across 12, 41 and six non-dedicated sampling days respectively (Northridge et al., 2018, 2019; Kingston et al., 2021). Dedicated sampling onboard longline vessels as part of the UK Bycatch Monitoring Programme in 2015, 2016 and 2018 reported no marine mammal bycatch across 12, 36 and 25 dedicated sampling days respectively (Northridge et al., 2016, 2017, 2019).

Evidence from outside of the UK for harbour porpoise bycatch from longlines is also limited, but similarly indicates low levels of bycatch. In Spain, no incidental catches of cetaceans were reported during an observer programme in 1994 across 547 longline hauls, nor within another programme from 1996 to 2000 covering 11 hauls on longline vessels (CEC, 2002). Similarly, no harbour porpoise were recorded as bycatch during fishing effort days observed aboard line vessels across the OSPAR region from 2005 to 2021 (ICES, 2021).

Evidence classifying the risk posed by different fishing gears for harbour porpoise bycatch indicates that lines likely pose a low risk. Expert participants of the ICES WGBYC in 2019 classified lines (including hand and pole lines, trolling lines, drifting longlines and set longlines) as low risk for harbour porpoise bycatch (ICES, 2019). Similarly, through Productivity Susceptibility Analysis, Brown et al. (2013) estimated harbour porpoise to have a low-risk score for bycatch from longlines in Irish waters based on their productivity, susceptibility and the spatial overlap between harbour porpoise distribution and fishing effort (Brown et al., 2013).

6.2 Indirect impacts

Indirect impacts of lines on harbour porpoise include the removal of target and non-target prey species and physical loss, change or damage to supporting habitats.

6.2.1 Removal of target and non-target prey species

No evidence was found investigating how fishing effort by lines may impact prey availability and harbour porpoise diet; consequently, a more general review has been conducted.

As described in section 2.3, line fisheries in the UK may target a range of demersal and pelagic fish species. Given that harbour porpoise feed mainly on small shoaling demersal and pelagic fish species (section 3.3), there is the potential for overlap with the species targeted by line fisheries (section 2.3). For example, one of the main target species for commercial longlines in the UK is cod (Seafish, 2023e), which belongs to one of the 'big four" prey guilds targeted by porpoise (section 3.3). Consequently, fishing for cod by line fisheries has the potential to reduce the availability of this prey type to harbour porpoise, which could in turn lead to porpoise switching to other, potentially less preferential, prey species (Santos and Pierce, 2003). However, the minimum conservation reference size for cod (35 cm) is larger than the length of prey items typically taken by porpoise (Hoekendijk et al., 2018; MMO, 2018).

As discussed for nets (section 5.2.1), the impact of line fishing on porpoise by removal of prey species will be dependent on the fishery and geographical area. Each line fishery may target different species, for example, in UK waters the main target species for jigging are cod, mackerel, pollock, saithe and squid, whilst trolling mainly targets bass, and commercial longlines target a range of demersal species (section 2.3). Although harbour porpoise have a varied diet, in any one area porpoise may focus primarily prey on two to four species (Santos and Pierce, 2003); therefore, any potential impacts of line fishing on prey availability may also vary by geographic area. In the North Sea, sandeels and whiting contributing markedly to energy available for porpoise (Ransijn et al., 2019), and such species are more likely the target of demersal and midwater trawls respectively rather than line fisheries (section 2).

Although there is substantial evidence of other cetacean species depredating on (taking fishing from) longlines, evidence of harbour porpoise interaction with longlines is limited (Gilman et al., 2006). Natural England have advised that it is unlikely for cetaceans in general to consume dead prey (Natural England pers. comms., 2022).

Bycatch from longlines in the UK might include pelagic and demersal fish species (Seafish, 2023e); thus, there is the potential for longlines to also impact harbour porpoise by removing non-target fish species. However, due to the ability to be selective through varying hook size, choice of bait and where to shoot gear there is generally little bycatch from line fisheries and the fishery is also operated mostly on a small scale in the UK (Seafish, 2023e). This suggests that longlines fisheries are unlikely to have significant impact on prey availability for harbour porpoise through removal of non-target species.

While literature suggests that there could be some overlap between the species targeted by lines and harbour porpoise prey, it remains challenging to distinguish the impacts of lines from cumulative impacts of multiple contributing factors (such as removal of prey by other fisheries, and impacts from other anthropogenic activities and climate change), which can also reduce prey availability and change prey distribution. The volume of fish removed from lines activities is lower than other fishing gears such as trawls in the UK (MMO, 2023). Therefore, given that line fisheries remove relatively low amounts of fish - and levels of fish bycatch are also likely low (Seafish, 2023e) - any impact to harbour porpoise through removal of prey by line fishing may be limited. MMO recommend that this should be monitored with the change in other contributing factors and reviewed at a more local level (site level assessment) due to the variation in impacts and to take account of site specifics (such as fishing level activity).

6.2.2 Physical loss, change or damage to supporting habitat

Anchored lines may cause physical loss, change or damage to supporting habitats through abrasion, disturbance and penetration of seabed and subsurface substrates (Stage 3 Fishing Gear MPA Impacts Evidence Anchored Nets and Lines document[3]).

Information on supporting habitats for harbour porpoise is provided in section 3.4. Habitats which may be impacted by pressures from anchored lines are sand, mud and mixed sediment habitats. The specific pathways through which anchored 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[3].

The impacts to harbour porpoise from gears interacting with supporting habitats are challenging to understand due to their complexity and the limited evidence available. There is a potential pathway for lines (mainly bottom-set lines) to disturb sand, mud and mixed sediment habitats, particularly at high levels of fishing intensity (Hall et al., 2008). Areas with a greater concentration of fishing activity will likely present a higher risk, particularly when overlapping spatially with other industries, leading to in-combination effects (Stage 3 Fishing Gear MPA Impacts Evidence Anchored Nets and Lines document[3]). However, anchored lines are unlikely to adversely affect these sandbank and sediment features and the interaction of lines and associated anchors with the seabed is likely to be minimal (Stage 3 Fishing Gear MPA Impacts

Evidence Anchored Nets and Lines document[3]). Therefore, the pressures that line fishing may have on supporting habitats is unlikely to be at a scale that will have a significant impact on porpoise prey species.

Overall, the interaction of lines with the seabed is likely to be minimal, and due to their nature any impact to harbour porpoise is expected to be low; therefore, a significant impact is not expected. However, site level assessments are required to consider the local characteristics, activity levels and operations.

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 harbour porpoise MPAs in consideration, this may contribute to the protection of harbour porpoise supporting habitat in certain areas.

6.3 Summary of the effects of lines on harbour porpoise

Lines have the potential to impact harbour porpoise. As such, site level assessments are required to determine whether management may be needed for MPAs protecting harbour porpoise. The pressures of most concern that need to be assessed further in site level assessments are:

- bycatch;
- removal of target and non-target prey species.

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.

7 Traps

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

Direct impacts

- Harbour porpoise bycatch (removal of non-target species).

Indirect impacts

- Removal or target and non-target prey species;
- Physical loss, change or damage to supporting habitat.

7.1 Direct impacts

Direct impacts of traps on harbour porpoise include the removal of non-target species (i.e., harbour porpoise bycatch).

7.1.1 Harbour porpoise bycatch (removal of non-target species)

Limited evidence is available regarding bycatch of harbour porpoise associated with pots and traps. As found in IAMMWG (2015), the most concerning gear types are nets and the limited data available suggests that harbour porpoise bycatch does not occur at a large scale in other fisheries (IAMMWG et al., 2015).

Small cetacean bycatch may be associated with abandoned or lost gear, with recordings of bottlenose dolphins being entangled in “ghost” ropes attached to pots and traps (Stelfox et al., 2016); however, this pressure is considered under section 9.2.2 in the ‘vessel presence’ review (as it is relevant to all fishing gears).

The UK Bycatch Monitoring Programme provides limited data on harbour porpoise bycatch from traps, with no observers placed onboard trap or potting vessels in 2017, 2018 or 2019 (Northridge et al., 2018, 2019; Kingston et al., 2021). No marine mammal bycatch was reported from five strings of lobster pots that were opportunistically monitored in ICES area VIIf in 2013, nor from one observation day for pots operated in ICES area IVb in 2014 (Northridge et al., 2014, 2018).

Evidence from outside of the UK waters suggests that harbour porpoise bycatch arising from traps is potentially limited. The ICES WGBYC reports in 2019 and 2020 reported no harbour porpoise bycatch was associated with traps, despite other marine mammals (including grey seals) being recorded as bycatch and large whale entanglements also being associated with traps (ICES, 2019, 2020a). Similarly, no harbour porpoise were recorded as bycatch during fishing effort days observed aboard trap vessels across the OSPAR region from 2005 to 2021 (ICES, 2021).

Evidence suggests that traps pose a low risk for harbour porpoise bycatch. Expert participants of the WGBYC in 2019 classified pots as having a low risk of harbour porpoise bycatch (ICES, 2019). Similarly, through Productivity Susceptibility Analysis, Brown et al., (2013) estimated a low-risk score for bycatch of harbour porpoise from pots in Irish waters based on porpoise productivity, susceptibility and the spatial overlap between species distribution and fishing effort. The draft UKDPCS concurs that bycatch events from traps are very rare, which suggests that individual animals may be able to avoid traps (The Scottish Government, 2021). The draft UKDPCS assessed harbour porpoise as having medium vulnerability to bycatch from creels and pots in UK waters (due to high sensitivity of individual animals and medium exposure to the pressure), with the medium vulnerability classification marked as low confidence due to contradictory evidence. The draft UKDPCS recommends that no management measures are required for bycatch of harbour porpoise from creels and pots in UK waters (or current measures are considered adequate) but further research was recommended (The Scottish Government, 2021).

7.2 Indirect impacts

Indirect impacts of traps on harbour porpoise include the removal of target and non-target prey species and physical loss, change or damage to supporting habitats.

7.2.1 Removal of target and non-target prey species

No specific evidence has been found investigating how fishing by traps may impact prey availability and harbour porpoise diet; consequently, a more general review has been conducted.

Traps and pots in the UK are predominately used to target shellfish, such as crab and lobsters, as well as whelks (section 2.4). Given that porpoise may feed on crustaceans (section 3.3) and crabs and other crustaceans have been found in the stomachs of harbour porpoise (Santos et al., 2004), there is the potential for overlap between porpoise prey and the species targeted by trap fisheries. However, crustaceans are considered of less importance to harbour porpoise diet, particularly in comparison to the four main prey guilds (section 3.3). Therefore, given that the majority of harbour porpoise diet is not in competition with traps, harbour porpoise are unlikely to be negatively impacted by removal of target species from UK trap fisheries. However, as for other fishing gears, the potential impacts of prey removal by traps may depend on the fishery (and its target species) alongside other factors such as overlap with seasonal and/or spatial differences in the prey targeted by harbour porpoise (IAMMWG et al., 2015).

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 also 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). Consequently, given the low levels of bycatch species associated with traps and pots, these fisheries are unlikely to have significant impact on prey availability for harbour porpoise through removal of non-target species.

Overall, it is challenging to unpick the impacts of traps specifically from cumulative impacts of other contributing factors (such as removal of prey by other fisheries, and impacts from other anthropogenic activities and climate change), which may also reduce prey availability and distribution. However, as traps mainly target non-fish species and trap fisheries in UK waters remove low amounts of fish compared to other fisheries (MMO, 2023), any impacts from traps to harbour porpoise through removal of prey species is likely to be negligible.

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 (Stage 3 Fishing Gear MPA Impacts Evidence Traps document[3]).

Information on supporting habitats for harbour porpoise is provided in section 3.4. Habitats which may be impacted by pressures from traps are sand, mud and mixed sediment habitats. 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[3].

The impacts to harbour porpoise from gears interacting with supporting habitats are challenging to understand due to their complexity and the limited evidence available. There is a potential pathway for traps to disturb sand, mud and mixed sediment habitats, particularly at high levels of fishing intensity (Hall et al., 2008). Areas with a greater concentration of trap activity or where the gear moves across the seabed (for example due to tidal activity) will likely present a higher risk of potentially impacting supporting habitats, particularly when overlapping spatially with other industries, leading to in-combination effects (Stage 3 Fishing Gear MPA Impacts Evidence Traps document[3]). However, traps are unlikely to have adversely effects on sandbank and sediment features (Stage 3 Fishing Gear MPA Impacts Evidence Traps document[3]) and thus any negative impacts on harbour porpoise through damage to supporting habitats (such as spawning and nursery area), is unlikely to be at a scale that will have a significant impact on porpoise prey species. The draft UKDPCS recommends that no management measures are required for the pressure of 'change / removal to supporting habitat' of harbour porpoise but further research was recommended (The Scottish Government, 2021).

Overall, due to the nature of traps, no significant impact to harbour porpoise through damage to supporting habitats is expected; however, site assessments are recommended to review site specifics. 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 harbour porpoise MPAs in consideration, this may contribute to the protection of harbour porpoise supporting habitat in certain areas.

7.3 Summary of the effects of traps on harbour porpoise

Traps have the potential to impact harbour porpoise. As such, site level assessments are required to determine whether management may be needed for MPAs protecting harbour porpoise. The pressures of most concern that need to be assessed further in site level assessments are:

- bycatch;
- removal of target and non-target prey species.

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.

8 Midwater gear

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

Direct impacts

- Harbour porpoise bycatch (removal of non-target species).

Indirect impacts

- Removal or target and non-target prey species.

8.1 Direct impacts

Direct impacts of midwater gear on harbour porpoise include the removal of non-target species (i.e., harbour porpoise bycatch).

8.1.1 Harbour porpoise bycatch (removal of non-target species)

Midwater towed gear

Limited evidence is available regarding bycatch of porpoise associated with midwater gear, such as midwater pair trawls and midwater otter trawls, with some information provided by bycatch observer programmes (ICES, 2020a). However, as found in IAMMWG et al. (2015), the most concerning gear types are nets and the limited data available suggests that harbour porpoise bycatch does not occur at a large scale in other fisheries.

The UK Bycatch Monitoring Programme indicates that midwater gears are associated with low levels of harbour porpoise bycatch (Defra, 2017, 2019). No cetacean bycatch was reported from onboard midwater trawlers (including midwater otter and midwater pair trawls) in 2017 and 2018, covering 116 sampling days (including 2 non-dedicated days) and 131 sampling days (including 2 non-dedicated days) respectively (Northridge et al., 2018, 2019). Furthermore, observations of the Lyme sprat fishery on five dedicated sampling days on midwater trawls in 2019 reported no marine mammal bycatch (Kingston et al., 2021). Likewise, non-dedicated sampling observations focused on commercial fish discards onboard midwater trawls in 2019 from the English and Welsh Data Collection Framework programmes, recorded no marine mammal bycatch (Kingston et al., 2021).

Annual monitoring targets for midwater trawl fisheries in the UK were deliberately reduced in 2016 in part due to low incidence of protected species bycatch being observed in most midwater trawl fisheries (Northridge et al., 2017). As stated in the draft UKDPCS, despite considerable monitoring, no harbour porpoises have been recorded as bycatch in midwater trawls (The Scottish Government, 2021). Midwater trawls also account for a low percentage of overall UK fishing effort. From the UK Sea Fisheries Statistics, for the over 10 m UK fishing fleet, midwater mobile gears accounted for approximately 1 to 2% of UK fishing effort by days at sea in 2021 (MMO, 2023). Such evidence suggests that harbour porpoise bycatch is likely not a major issue for midwater gear fisheries in UK waters.

Levels of bycatch may, however, vary between midwater fisheries, with bycatch of small cetaceans a particular concern for bass pair trawl fisheries in the western English channel (Northridge, 2006). Pair trawling is a fishing method whereby a trawl is towed by two boats simultaneously, with the trawl held open by the distance between the vessels (Seafish, 2023f). Short-beaked common dolphins can have significantly higher abundance in the presence of pair trawlers, which consequently pose a risk of bycatch (N. de Boer, 2012). Although harbour porpoise have been observed in the presence of pair-trawlers in UK waters (N. de Boer, 2012), less evidence is available to suggest that bass pair trawling may result in harbour porpoise bycatch, with common dolphins being the only cetacean species observed as bycatch across 187 tows in the English Channel between 2001 and 2003 (Northridge and Thomas, 2003). From 2000 to 2004, over 300 common dolphin were recorded as bycatch in the bass trawl fishery in the south-west, but no bycatch of harbour porpoise was recorded (Jepson, 2005). Such evidence suggests that cetacean bycatch risk posed by bass pair trawlers may vary with species and is likely relatively low for harbour porpoise.

Evidence from outside of UK waters also suggests that, although harbour porpoise are caught in midwater trawls, the total number of bycaught individuals may be low. Analysis by the ICES WGBYC between 2005 and 2018 indicated that in the Bay of Biscay, harbour porpoise bycatch was highest in pelagic trawl fisheries (ICES, 2020a); however, gillnets posed the highest threat as the larger fleet size likely lead to higher total mortality (ICES, 2020a). Using data from 2015 to 2017, no incidents of harbour porpoise bycatch were observed from midwater otter and midwater pair trawls in the Celtic Sea ecoregion or the Greater North Sea ecoregion (ICES, 2019). In contrast, harbour porpoise were observed as bycatch in midwater pair trawls in the Celtic Sea using data submitted from OSPAR countries for the years 2005 to 2021, with four porpoise observed across approximately 1,413 days of fishing effort (ICES, 2021).

Although evidence from the UK and from ICES suggests that overall levels of bycatch from midwater trawls may be low, midwater trawls may pose a moderate risk to cetaceans relative to bottom trawls (Fertl and Leatherwood, 1997; Brown et al., 2013). Following a review of global data covering 25 cetacean species, Fertl and

Leatherwood (1997) found that individuals of more cetacean species (including pilot whales, *Globicephala* spp., common dolphins, *Delphinus* spp., and harbour porpoise) were caught in midwater trawls compared to bottom trawls possibly because 1) midwater trawls tend to target small schooling pelagic fish species, which are often the same as those preyed upon by small cetaceans, including harbour porpoise (section 3.3); 2) midwater gear is trawled at a relatively higher speed; and/or 3) midwater trawls can be much larger than bottom trawls (Fertl and Leatherwood, 1997).

Evidence suggests that midwater gear poses low risk for harbour poise bycatch. Expert participants of the WGBYC in 2019 classified midwater trawls (midwater otter trawls and midwater pair trawls) as low risk for harbour porpoise bycatch (ICES, 2019). Similarly, through Productivity Susceptibility Analysis, Brown et al. (2013) estimated harbour porpoise to have a low-risk score for bycatch from midwater trawls in Irish waters based on porpoise productivity, susceptibility and the spatial overlap between harbour porpoise distribution and fishing effort (Brown et al., 2013). The level of risk posed by bycatch from midwater trawl fisheries can depend on the marine mammal species being assessed, with the risk of bycatch from pair trawl fisheries being relatively low for harbour porpoise compared to common dolphins. The draft UKDPCS assessed harbour porpoise as having medium vulnerability to bycatch from trawls in UK water due to high sensitivity of individual animals and medium exposure to the pressure (The Scottish Government, 2021). However, the draft UKDPCS does not differentiate between midwater and bottom trawling, so such scores are not specific to midwater gear. The draft UKDPCS recommends that current measures are considered adequate for bycatch pressure exerted by trawls on harbour porpoise in UK waters, but further research is recommended.

Purse seines

There is limited evidence of harbour porpoise bycatch occurring in purse seines in UK waters. Harbour porpoise bycatch was not observed by the UK Bycatch Monitoring programme across 14 days of observations aboard purse seines/ring net vessels in 2019 or 13 days at sea in 2018 (Northridge et al., 2019; Kingston et al., 2021). From outside of the UK, there is evidence of harbour porpoise being encircled by purse seines in the sardine fishery in Portuguese waters; however, unlike common dolphins, no harbour porpoise mortality was recorded (Marçalo et al., 2015). Purse seine fishing for tuna in the eastern tropical Pacific is also known to cause bycatch of common dolphins but this fishery is not notably linked to harbour porpoise bycatch (Lewison et al., 2004).

The draft UKDPCS assessed harbour porpoise as having medium vulnerability to bycatch from purse seines in UK waters due to high sensitivity of individual animals and medium exposure to the pressure; however, purse seines were grouped together with “trawls” (The Scottish Government, 2021). Given that purse seines likely account for less than 2% of UK fishing effort in terms of days at sea (Kingston et al., 2021), exposure of harbour porpoise to bycatch pressures from purse seines in UK waters may be minimal. Expert participants of the WGBYC in 2019 also classified purse seines as low risk for harbour porpoise bycatch (ICES, 2019).

8.2 Indirect impacts

Indirect impacts of midwater gear on harbour porpoise include the removal of target and non-target prey species.

8.2.1 Removal of target and non-target prey species

Midwater towed gear

As described in section 3.3, harbour porpoise feed predominantly on demersal and pelagic fish; consequently, there is the potential for overlap between porpoise prey and the pelagic species targeted by midwater gears (section 2.5). There is likely particular potential for resource competition for small shoaling species (such as whiting, sprat, herring and horse mackerel), which are both prey species of harbour porpoise (Santos and Pierce, 2003) and targeted by midwater trawls (Montgomerie, 2022). Furthermore, for these small shoaling pelagic species, the minimum conservation reference sizes tend to be under 30 cm (MMO, 2018). Thus, given that harbour porpoise tend consume prey under 30 cm in length (Hoekendijk et al., 2018), there may be direct overlap between the fish targeted by midwater trawls and those targeted by harbour porpoise. This potential for direct competition between commercially target species and prey items, well as the large quantities of pelagic fish landed by pelagic trawls in in UK waters (e.g., MMO, 2023), suggests that midwater gears may be a particular concern for impacts on porpoise through the removal of target species pressure.

With regards to bycatch, pelagic trawls may accidentally catch juveniles of the target species, but otherwise pelagic trawls are often species-specific in operation (Seafish, 2023g). Gear modifications, such as the mesh size at the cod end, can be set to suit the physical size of the target species (Seafish, 2023g). Selectively is also undertaken through skipper experience, for example, many of the target species will have migration patterns and thus skippers can select the areas and times of year when the target species will likely be present (Seafish, 2023g). Furthermore, echo-sounders and sonar screens can also be used to differentiate species and ensure that target species are selected (Seafish, 2023g). Consequently, potential impacts of midwater trawls on porpoise through the removal of non-target (prey) species pressure may be more limited.

As discussed for other gears, the impact of midwater gears on porpoise by removal of prey species will be dependent on the fishery and its target species, as well as geographic area. As mentioned in section 3.3, porpoise may focus on two to four species in any given area with sandeels and whiting being particularly important components of harbour porpoise diet in the North Sea. Although midwater trawls are not used to target sandeels, there could be particular resource competition for whiting in the North Sea, which are one of the main target species of midwater trawls (Seafish, 2023g).

Potential impacts of prey removal by midwater gear may also depend on the age of harbour porpoise. Juvenile porpoise cannot dive as deep as adults and could be prevented from catching and eating big prey due to their small size (Santos and Pierce, 2003). This may make juvenile animals more vulnerable to competition with midwater gears compared to adults, which may have more flexibility in foraging behaviour (Santos and Pierce, 2003; Hoekendijk et al., 2018).

Regarding specific literature for pelagic species, Santos and Pierce (2003) discuss the exploitation of herring stocks in the North Sea. Following overfishing fishing of herring and a decline in herring stocks between the 1950s and 1970s, the authors suggest that harbour porpoise in the northeast Atlantic may have switched prey species, from herring to a diet based on sandeels, whiting and other gadoids (Santos and Pierce, 2003). It is also noted that this decline in herring stocks may have caused a decline in harbour porpoise numbers in the southern North Sea (Santos and Pierce, 2003). However, Santos and Pierce (2003) note that this is just one of several hypotheses for an apparent decline in harbour porpoise numbers in the North Sea and that despite herring being overfished off Scottish coasts there is no evidence for a parallel decline in porpoise numbers. In the case of herring, it has a high calorific value (Ransijn et al., 2019) so a switch in diet to lower calorific species could have short-term effects (such as weight loss) and longer-term impacts (such as affecting productivity and population survival) (Santos and Pierce, 2003). Booth (2020) reports significant energy differences in prey quality, for example whiting provide 4.2 kilojoules per gram (kJ/g) compared to sprat that provide 7.6 kJ/g (Pedersen and Hislop, 2001; Wanless et al., 2005). Literature reports that, for harbour porpoise, 24 hours of near fasting could cause 3% to 5% reduction in body mass (Kastelein et al., 2019).

Further to potential impacts of prey removal on porpoise energy intake, it is important to note that changes in species composition as a result of overfishing could result in longer term impacts on trophic levels and prey availability (Pinnegar et al., 2002). For example, changes in trophic levels may result in reduced biodiversity, altering the local fish species and shifting benthic communities towards more short-lived and smaller species. This could then have knock-on impacts to top predators, such as harbour porpoise, by leading predators to switch prey or change foraging areas (Reijnders, 1992; Santos and Pierce, 2003).

Overall, it is challenging to understand the full impacts of different fishing gears and their impacts on harbour porpoise prey; and any cumulative impacts from other contributing factors (such as removal of prey by other fisheries, and impacts from other anthropogenic activities), which may reduce prey availability. Unlike nets and traps, midwater trawling is less limited to inshore areas and occurs throughout English waters, meaning impacts could be widespread and greater in areas of higher exposure. A site-specific assessment is recommended to consider local circumstances (for example prey preferences); however, JNCC and NE do note that this will be challenging.

Purse seines

Purse seines fisheries in the UK also target potential prey species, such as herring and mackerel (Seafish, 2023i). As such, as for midwater trawls, there is potential overlap between the target species of purse seines in the UK and harbour porpoise for pelagic fish (section 3.3). The minimum conservation reference size for herring is 20 cm, and either 20 cm (outside of the North Sea) or 30 cm (in the North Sea) for mackerel (MMO, 2018). Thus, similar to midwater trawls, given the tendency for porpoise to take prey under 30 cm (Hoekendijk et al., 2018), there may be direct overlap between the fish items targeted by purse seines and harbour porpoise. However, in contrast to midwater trawls, purse seines in the UK land much lower quantities of pelagic fish; for example, UK pelagic seines landed approximately 9,000 tonnes of pelagic fish into the UK and abroad in 2021 compared to approximately 370,000 tonnes landed by pelagic trawls (MMO, 2023). Purse seines in the UK are also thought to have very little bycatch, with the exception of potentially juveniles of the target species (Seafish, 2023i). Consequently, the scale of impacts from purse seines on prey availability may be limited by the smaller scale of purse seine fishing in UK waters.

8.3 Summary of the effects of midwater gear on harbour porpoise

Midwater towed gear and purse seines gears have the potential to impact harbour porpoise. As such, site level assessments are required to determine whether management may be needed for MPAs protecting harbour porpoise. The pressures of most concern that need to be assessed further in site level assessments are:

- bycatch;
- removal of target and non-target prey species.

Due in part to the purse seine fishing in the UK being at a small scale, any impacts from purse seines through bycatch of porpoise or removal of prey species are expected to be more limited. However, further assessment at a site level would still be required. 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.

9 Fishing vessel presence

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

Direct impacts

- Underwater noise;
- Visual disturbance;
- Death or injury by collision.

Direct and indirect impacts

- Contaminants;
- Litter.

9.1 Direct impacts

Direct impacts of bottom towed gear on harbour porpoise include behaviour disturbance from underwater noise, visual disturbance from vessel presence and death or injury from vessel collision.

9.1.1 Underwater noise

Anthropogenic noise can affect the behaviour of harbour porpoise, including interrupting foraging and communication behaviour, as well their ability to detect predators, and could also lead to increased stress (Fair and Becker, 2000; Wisniewska, Johnson, Teilmann, Siebert, et al., 2018; Booth, 2020). Merchant (2018) notes that the main source of anthropogenic ambient (continuous) noise is from shipping activity (which includes fishing vessels).

Commercial fishing activities produce noise through a range of sources, such as through engine noise, propeller noise, the use of fish-finding sonars and during gear deployment and retrieval (e.g., Daly and White, 2021). Limited information is available on the impacts of noise produced during fishing gear deployment and retrieval (especially for harbour porpoise), but there is evidence going back to the 1970's with regard to the reactions of fish species to trawling vessels (e.g., Ona and Toresen, 1988; Ona and Godø, 1990; De Robertis and Handegard, 2013). Trawled fishing gear is associated with additional noise during towing due to the gear components involved, for example winches on deck might cause vibrations against the hull, and trawl warps (cables connecting nets to the vessel) may create a humming noise as they move through the water column (Ona and Godø, 1990; Daly and White, 2021). Additionally, gear deployment may change the propeller pitch causing a sudden change in vessel noise (De Robertis and Handegard, 2013). Additional noise is produced as bottom towed gear is dragged along the seabed (Daly and White, 2021). However, engine noise (propeller 'cavitation', described by Koschinski, (2008) as the hissing noise coming from bubble formation and collapse due to pressure changes) is likely the main source of anthropogenic noise from fishing vessels (Ona and Toresen, 1988; Ona and Godø, 1990; De Robertis and Handegard, 2013). Vessel type and geographical location are expected to be one of several factors affecting the magnitude of impacts (for example, the depth of the water and underlying sediment will change acoustic properties) (Nowacek et al., 2007; Oakley et al., 2017). For example, Koschinski (2008) found that “observed behaviour reactions” of harbour porpoise to boats were stronger in shallow waters, presumably due to their ability to dive being restricted.

As noted above, there are extensive surveys reviewing the reaction of fish species to vessel noise. The literature suggests that fish can react (for example moving downwards) at approximately 300 to 500 m before a vessel arrives and can discriminate from ambient noise at distances greater than 2 km. The severity of the reaction varies with depth (as the shallower the animal the greater the reaction; with no avoidance observed at depths of 200 m to 500 m), as well as species (for example herring reoccupied waters 5 to 6 minutes after the disturbance, whereas gadoids took 9 to 11 minutes). Fish appear to have a stronger reaction with increased vessel speeds, with increased noise during trawling shown by increased avoidance (Ona and Toresen, 1988; Ona and Godø, 1990; De Robertis and Handegard, 2013).

Noise from commercial fishing vessels is generally considered alongside the impacts of ambient noise from marine activity (IAMMWG et al., 2015; Wisniewska et al., 2018) and may have behaviourally mediated effects. In contrast to sudden loud impulsive noise (such as from pile driving, underwater explosions and seismic surveys), noise from vessel engines is unlikely to cause physical trauma (IAMMWG et al., 2015). Instead, continuous noise from ship engines may result in masking impacts (where the harbour porpoise’s perception of a noise is affected by the presence of another), as well as behavioural changes, disturbance and potentially habitat reduction as harbour porpoises are displaced from their preferred habitat (Boyd, 2008; IAMMWG et al., 2015; Merchant, 2018). Wisniewska et al., (2016, 2018) argue that harbour porpoise have a near constant need to feed; although, while the exact rate is subject to discussion, harbour porpoise still appear to have high metabolic demands. This means that harbour porpoise are likely particularly vulnerable to foraging disturbance (Wisniewska et al., 2016). However, as noted by Booth (2020), the question regarding what constitutes a significant disturbance (“i.e. one that affects an animals’ probability of survival or reproducing”) is unclear (King et al., 2015; Nabe-Nielsen et al., 2018).

More broadly, evidence from studies in UK and European waters suggests that shipping noise can detrimentally affect harbour porpoise by masking, behavioural disturbance and habitat reduction (Merchant, 2018). Using 18 years of data from across 545 surveys, Heinänen and Skov (2015) modelled the distribution of harbour porpoise throughout UK waters. Shipping density had a strong influence on the presence and abundance of harbour porpoise, with a negative relationship being evident between the number of ships and the distribution of harbour porpoise in the Celtic and Irish Seas, and the North Sea (Heinänen and Skov, 2015). Using animal-borne sound and movement recording tags deployed on seven harbour porpoise in the Kattegat and the Belt seas in Danish waters, Wisniewska et al., (2018) investigated vessel noise experienced by harbour porpoise and the associated behaviour. During high noise levels from vessels (including possibly ferries and large ships, such as tankers, but also smaller fishing vessels), animals dived deeper and increased swimming effort, whilst echolocation sounds and prey-capture attempts decreased (Wisniewska et al., 2018). If exposed frequently to such noise, this increased energy expenditure on swimming and disrupted foraging behaviour may have long-term negative fitness consequences (Wisniewska et al., 2018). Arguments have been made that for small-toothed cetaceans (like harbour porpoise) who generally have poor hearing at low frequencies (Kastelein et al., 2002), the effects of vessel noise may be minimal due to most noise power from vessels being radiated at low frequencies (Dyndo et al., 2015). Nevertheless, porpoise have been shown to avoid vessels (Palka and Hammond, 2001) and can also react to the medium- and high-frequency components of vessel noise (Dyndo et al., 2015).

A 2015 literature review on harbour porpoise found that three anthropogenic pressures posed the greatest risk to harbour porpoise: 1) bycatch in static net fisheries; 2) acoustic disturbance through impulsive noise (for example from pile driving and seismic surveys); and 3) chemical pollution. Acoustic disturbance through continuous noise (such as from vessel presence) was considered of less importance, although this pressure might pose a moderate risk at a local level (IAMMWG et al., 2015). As part of the UK Marine Online Assessment Tool (which provides data to assess progress towards Good Environmental Status), the ambient noise indicator assessment estimated baseline levels of continuous (ambient) noise in UK waters (Merchant, 2018). At the levels estimated, it was unclear whether the ambient noise levels negatively affect marine life at the population or ecosystem scale (Merchant, 2018). Limited evidence is available on the extent to which fishing vessels contribute to continuous ambient anthropogenic noise. However, relative to larger ships (for example tankers) and faster vessels (for example ferries) that produce higher noise levels (Hermannsen et al., 2014; Erbe et al., 2019), commercial fishing vessels will likely have a lower contribution to ambient anthropogenic noise. Therefore, although fishing vessels may contribute to ambient noise, the risk of fishing vessels alone impacting harbour porpoise through underwater noise is likely to be low (IAMMWG et al., 2015).

9.1.2 Visual disturbance

Marine traffic can cause a disturbance response in harbour porpoises due to the presence of noise, as a reaction to a visual impact, or a combination of the two (David, 2002). Most studies of cetacean disturbance focus on the impacts of noise; however, most cetacean species have good eyesight both above and below the water, meaning visual disturbance could also be a pressure. Harbour porpoises use their eyesight along with echolocation to interact with other harbour porpoises, locate and hunt for prey and make sense of their environment (Pryor, 1990).

Disturbance to harbour porpoise can be caused by the presence of various different vessel types. These include but are not limited to fishing vessels (commercial and recreational), cargo ships, ferries, jet skis, speedboats, cruisers, ribs and are usually associated with higher levels of acoustic disturbance (Oakley et al., 2017).

Since the presence of a vessel usually produces both a visual and acoustic disturbance to harbour porpoise, it is hard to evaluate the specific differences between the two pressures. A two-year study from Lampedusa, Italy, found negative reactions of bottlenose dolphins to fast moving vessels, fishing vessels and engine-powered boats; however, there was no reaction to sailing boats (Papale et al., 2012), suggesting that visual stimulus has a lower significance in the disturbance response of bottlenose dolphins. However, studies suggest that bottlenose dolphins and harbour porpoise have differing abilities to detect approaching vessels (Oakley et al., 2017). According to some studies harbour porpoise have been observed to be negatively affected by any vessel regardless of whether it is powered by an engine, is moving or is stationary (Roberts et al., 2019); although, in contrast Oakley et al. (2017) did not show a negative response when vessels were stationary.

Oakley et al. (2017) studied the effects of vessel presence and watercraft activity around harbour porpoises in the Swansea Bay and south Gower area of the UK from February 2011 to May 2013. Out of 2,153 observed vessels, 39 (2%) involved interactions with harbour porpoise (Oakley et al., 2017). No interactions were classified as positive (following or moving towards a vessel), 74% were neutral (no apparent change in directional movement) and 26% were observed to be negative (moving away from a vessel or prolonged dives) (Oakley et al., 2017). Responses to vessels depended on the size and activity of a group prior to the encounter (Oakley et al., 2017). The authors suggest that animals in groups of two or more may warn each other of a perceived threat (causing the reaction) and/or if in a ‘familiar group’ then the mother may be more protective causing a negative response (Oakley et al., 2017). Koschinski (2008) also note that this could be due to the juvenile’s ability to move being limited. Oakley et al. (2017) also highlighted the significance of vessel speed and type in the response of harbour porpoise. The study results showed that out of 18 sightings of harbour porpoise near fishing vessels (made up of recreational and commercial), 14 had a neutral response, one returned after diving and three were not seen again (Oakley et al., 2017). Surprisingly, the study concluded that 70% of negative reactions were caused by vessels moving at a steady speed and there were no negative reactions to erratically moving vessels (Oakley et al., 2017). This contradicts previous observations regarding erratic movements and fast moving vessels (Jenkins, 2007; Koschinski, 2008; Veneruso et al., 2011). For example, Koschinski (2008) note that reactions were more significant in relation to vessels with erratic movements; with fast moving vessels (speed boats) causing escape reactions “even at considerable distances”.

Using the same methodology, Roberts et al. (2019) recorded the impact of vessels on the presence and behaviour of harbour porpoise from July to September 2017 in the coastal waters of Brixham, south-west England. Unlike Oakley et al. (2017), yachts were the most recorded vessel type and the study found the occurrence of harbour porpoise and their feeding behaviour reduced significantly with increased vessel frequency (Roberts et al., 2019). No harbour porpoise were observed in the presence of over 25 vessels and no resting behaviour was observed in the presence of over 10 vessels (Roberts et al., 2019). Both studies found evidence that vessel presence caused a reduction in foraging and feeding activities (Oakley et al., 2017; Roberts et al., 2019). Harbour porpoise have been recorded to react to fast-moving motor boats from a distance of approximately 150 to 300 m and react to all other types of vessels from distances of 10 to 1000 m (Koschinski, 2008; Dyndo et al., 2015; Oakley et al., 2017). Levels of habituation may lessen the impact of visual disturbance of vessels to harbour porpoise, for example Oakley et al. (2017) observed harbour porpoise exhibiting neutral behaviour around stationary iron-ore carriers and tug boats, sometimes alongside the ship. A survey within Ramsey Sound, Pembrokeshire, Wales by Lange (2012) found no relationship between the number of vessels (n = 502) and the number of harbour porpoises observed. It was proposed that as harbour porpoise had not been displaced they may have been able to "cope with existing disturbance" or that the level of vessel activity had not had a "significant enough impact" (Lange, 2012).

Alone, visual disturbance from vessels may not pose a large threat to harbour porpoise populations; however, coupled with other pressures associated with vessel presence (and cumulative impacts from other operations), visual disturbance may contribute to any negative impacts on the species. Given that visual disturbance has not been identified by previous reviews as a pressure to harbour porpoise in UK waters (IAMMWG et al., 2015), visual disturbance alone is not likely to impact porpoise at a population level. Evidence suggests that vessels regardless of if they are using a motor engine or not (Roberts et al., 2019) have the potential to interrupt foraging activities, potentially making harbour porpoise unable to meet their required daily intake of food, risking starvation, hypothermia and mortality (Leopold, 2015). Long-term disturbance may cause displacement to less favourable sites with fewer food resources or sheltered areas, again impacting population health. However, harbour porpoise are able to become habituated to visual disturbance in some cases (Oakley et al., 2017). Overall, from the review of the evidence above, it is challenging to determine the impacts of visual disturbance alone, with other vessel types and pressures (such as noise) likely being more significant.

9.1.3 Death or injury by collision

Collision is defined as the introduction of a physical object that may collide with harbour porpoise, and consequently result in injury or death and ultimately increased mortality. All vessels, including fishing vessels, have the potential to result in collision with harbour porpoise (vessel strikes). Injuries and mortalities from vessel strikes are reported mostly for slow-swimming large baleen whales (van der Hoop et al., 2015), with less literature available on ship strikes involving small cetaceans (Van Waerebeek et al., 2007; IAMMWG et al., 2015).

Limited evidence on possible vessel strikes involving harbour porpoise in UK waters is available from strandings data. The Cetacean Strandings Investigation Programme (CSIP) records information on cetaceans, marine turtles and basking sharks that strand around English and Welsh shores each year and undertake routine necropsies to determine the cause of death (ICES, 2020a). In 2017, CSIP undertook post-mortems of 73 harbour porpoise and determined that one died from physical trauma of an unknown cause (Deaville et al., 2017). From 2005 to 2010, CSIP undertook necropsies on 478 harbour porpoise, of which four individuals died as a result of physical trauma from a ship or boat strike and two individuals died from physical trauma of an unidentified cause (Deaville et al., 2010). The CSIP reports define physical trauma from boat or ship strikes as trauma injuries consistent with impact from a boat or ship, including blunt trauma to dorsal/lateral aspect of the body wall and/or injuries consistent with propellor strike (Deaville et al., 2017). Whilst physical trauma from an unidentified cause are cases where there is no conclusive evidence of cause, but the trauma could be a result of vessel strike, bycatch or bottlenose dolphin attack (Deaville et al., 2010, 2011, 2017). This means that the actual numbers of death from vessel strikes may be higher than those recorded and does not take account for animals that do not die (and strand) following injuries received from vessel strikes.

Further to the results from CSIP above, the Scottish Marine Animal Stranding Scheme (SMASS), which coordinates surveillance of strandings on Scottish coastlines, has previously identified physical trauma as a cause of death for necropsied harbour porpoise (SMASS, 2012). Between 2012 and 2015, physical trauma was recorded as the cause of death for six out of 69 (~9%) of the animals examined, with the most common cause of death (29%) recorded as attack by bottlenose dolphins. However, 191 of the 280 harbour porpoise reported between 2012 to 2015 were not examined (due to accessibility issues and the condition of the animal), meaning the actual numbers could be higher (SMASS, 2012).

Although vessel strikes on harbour porpoise in UK waters likely does occur, the risk posed specifically by commercial fishing vessels is uncertain but likely to be low. Harbour porpoise can exhibit ship-avoidance behaviour, which may reduce the frequency of vessel strikes (IAMMWG et al., 2015; Schoeman et al., 2020). Faster vessels, such as ferries, as well as recreational watercraft with unpredictable fast movements (for example jet skis) are more likely to pose a higher risk to small cetaceans relative to commercial fishing vessels (Carrillo and Ritter, 2010; IAMMWG et al., 2015). JNCC’s literature review considered collision of less importance relative to other pressures and of low risk to harbour porpoise in UK waters (IAMMWG et al., 2015). As such, the risk posed specifically by vessel strikes from commercial fishing vessels will likely be lower still.

9.2 Direct and indirect impacts

In this section, pressures from vessel presence that can have both direct interaction with harbour porpoise and indirect impacts are reviewed.

9.2.1 Contaminants

Contaminants are substances capable of contaminating harbour porpoise, their prey and/or their habitat, with negative direct or indirect impacts. For the purpose of this review ‘contaminants’ includes the following pressures: hydrocarbon and polycyclic aromatic hydrocarbons (PAH) contamination; transition elements and organo-metal (for example tributyltin, TBT) contamination; and synthetic compound contamination (for example pesticides, antifoulants, pharmaceuticals). As the literature review of IAMMWG et al. (2015) suggests, such contaminants can cause effects on water and prey quality, bioaccumulation through ingestion of contaminated prey and health issues such as immunosuppression and reproductive disruption in aquatic mammals (e.g., Jepson et al., 2005; Jepson and Law, 2016; van den Heuvel-Greve et al., 2021; Williams et al., 2021)

Regarding commercial fishing activity, potential sources of sources include any contaminants present in the substrate (such as biocides/historic chemicals from industrial processes) being released during the direct interaction with the gear mobilising the sediment (for example bottom towed gear and anchored gears) or directly from the vessels through accidental spills/leaks, operational discharges (for example ballast water) and antifouling paints (IAMMWG et al., 2015). Deliberate releases are already prohibited and accidental discharges from fishing vessels leading to significant releases are extremely rare. Pathways for accidental discharges will not be considered further in this section as the likelihood of events is low; thus, such instances pose a low risk to harbour porpoise and management measures such as byelaws would not be suitable.

As noted above, one pathway for contaminants from commercial fishing activity is through gears contacting the seabed leading to the mobilisation of sediments into the water column. If this sediment contains trapped contaminants, then these can be released into the water column causing a potential deterioration in water quality, impacting the prey and the supporting habitats of harbour porpoise (IAMMWG et al., 2015). The risk of any contaminated sediments being released will depend on the substrate present (with finer sediments such as sand and mud having a greater ability to trap contaminants, be more easily suspended into the water column and disperse further).

Williams et al. (2020, 2021) report that even though polychlorinated biphenyls (PCBs) were banned in Europe during the mid-1980s, their legacy means that PCBs are still entering the marine environment (and it is likely that release is still taking place from ‘diffuse’ sources). Williams et al. (2020) reported that PCB blubber concentrations of 1 milligram (mg) per kilogram (kg) lipid corresponds with a 5%

increase in the risk of infectious disease mortality (with factors such as age, sex, nutritional condition, and season having a significant impact on an individual's risk). Results of 814 tissue samples collected between 1990 and 2017 indicate that PCB concentrations have fallen below the commonly used threshold for toxic effects (Williams et al., 2020). However, harbour porpoise are still at risk as the rate of decline is slow (and slower when compared to levels in overall trends for fish and other pollutants) (Williams et al., 2020). Concentrations of PCB also varied geographically with a steady decline over the study period for Wales, the east and west of England (Williams et al., 2020). Contrary to this, Scotland experienced a peak in PCB levels around 2004 before PCB levels also began to decline, with the authors suggesting that this peak could have been due to spread from other areas (Williams et al., 2020).

The release of ballast water can result in contaminant release (and other pressures for example invasive non-native species and deoxygenation); however, all fishing vessels under 45 m in length should have solid ballast (as per the Fishing Vessels (EC Directive on Harmonised Safety Regime) (Amendment) Regulations 2003[5]). The majority of fishing vessels utilising English waters are under 45 m (MMO, 2023) meaning that the risk posed by ballast waters is low. Another potential source of contaminants from vessels is from antifouling treatments on the vessel hull. IAMMWG et al., (2015) report that literature suggests that butyltins (historically used as anti-fouling treatments) may impact the immune systems of harbour porpoise and can accumulate with age (e.g., Strand et al., 2005). The full extent of these impacts as detailed by IAMMWG et al. (2015) are typically delayed and challenging to detect (e.g., Murphy et al., 2010). The risk of anti-fouling contamination is considered low as TBT has been banned on vessels under 25 m in length since 1987 and on all vessels since 2008. Copper wash can enter the marine environment but if sites are dynamic (for example have strong tidal currents) then this is not likely to accumulate (International Maritime Organization, 2012). Management of transition elements, organo-metal and synthetic compound contamination occurs through legislation such as the International Convention for the Prevention of Pollution from Ships 1973 (International Maritime Organization, 2019).

The pathways discussed above introduce the potential sources of contaminants in the marine environment. This contamination has the potential to impact harbour porpoise, their prey and habitats through bioaccumulation ascending through the trophic levels and generations (IAMMWG et al., 2015; Williams et al., 2020). Cetaceans are likely particularly vulnerable to potential longer-term impacts of contaminants as these animals occupy the higher trophic levels and are relatively long-lived species. These reports suggest that contaminants may negatively affect health, nutrition, growth, reproduction, susceptibility to infections and therefore mortality rates (e.g., Aguilar, 1985; Aguilar and Borrell, 1995; IAMMWG et al., 2015; Williams et al., 2020, 2021). A study by van den Heuvel-Greve et al. (2021) showed

[5] https://www.legislation.gov.uk/uksi/2003/1112/made

that contaminants can be transferred from female harbour porpoise to their offspring while in the placenta and once born during lactation. Alongside potentially impacting immunosuppression and female reproductive processes, a study by Williams et al. (2021) found that the reproductive success of male animals in 'good health' was also reduced with higher concentrations of PCBs, which could further impact populations.

Overall, it is challenging to understand the exact sources of contamination and impacts on harbour porpoise as they are a highly mobile species (IAMMWG et al., 2015). Following a review of the literature above and advice from JNCC and NE, the risk to harbour porpoise is considered low (in relation to fishing).

9.2.2 Litter

Litter may arise from fishing vessels, for example from galley waste, fish boxes, floats/buoys, nets, ropes, lines, pots, weights and micro-plastic particles resulting from disintegration of plastic gear (Lozano and Mouat, 2009; IAMMWG et al., 2015; Philipp et al., 2021). Litter from fishing activity may end up in the marine environment from loss of gear due to wear and tear during operational use, accidental loss of gear and gear parts which cannot be retrieved and intentional dumping of unwanted gear or loss due to poor handling practices (e.g. clippings from net mending) (IAMMWG et al., 2015; OSPAR, 2020).

As noted by Stelfox et al. (2016), fishing gears would historically have been made from natural materials that decompose relatively quickly; however, with advances in gear technology and design, fishing gears often consist of synthetic materials (e.g. plastics) that can remain unchanged for decades. The loss or abandonment of fishing gears could result from passive gears (nets/pots) during adverse weather events and demersal gears being cut free after snagging on the seabed to ensure the safety of the fishing vessel and crew. It should also be noted that fishermen often make substantial efforts to recover any lost or abandoned gear; however, it is not always possible to safely do so. This gear has the potential to continue 'fishing' and is referred to as 'ghost-fishing' (IAMMWG et al., 2015; Stelfox et al., 2016). It is challenging to quantify the amount of lost, abandoned or discarded gear. A review by Stelfox et al. (2016) estimated that more than 64,000 tonnes of fishing gear are lost globally every year.

Ghost fishing presents a risk to harbour porpoise as they can be caught as bycatch (IAMMWG et al., 2015). Despite this, IAMMWG et al. (2015) did not find evidence of harbour porpoise bycatch in ghost gear between 2000 and 2010 so overall the risk is thought to be low. A CSIP report for the period 2005 to 2010 noted that the principal cause of death of 71 of 478 harbour porpoise examined through post-mortem was entanglement in fishing gear (bycatch), although no animals showed entanglement in marine litter (Deaville et al., 2010). It is not possible to determine if the bycatch was from gear in active use or ghost gear (Deaville et al., 2010).

Stelfox et al. (2016) have undertaken a review into ghost gear entanglement and a summary of some of their findings are found below. The type of net (for example static versus moving; monofilament versus multifilament) and time in the water (for example level of bioaccumulation build up) are reported as factors which may impact the fishing efficiency of the ghost gear (along with other factors such as depth and obstacles). For example, gear in rocky habitats may snag on a rock causing it to rip, creating a larger hole, allowing for larger animals to become stuck. Monofilament (single fibre) gear is described as having higher catch rates, with literature suggesting that this is potentially due to it being less visible (Ayaz et al., 2006; Stelfox et al., 2016). Over time, sessile organisms can accumulate on the gear (referred to as 'bio-fouling') making the gear more visible as it builds up (Ayaz et al., 2006; Baeta et al., 2009; Stelfox et al., 2016). The rate of bioaccumulation depends on environmental factors such as temperature and depth (for example the deeper you are the less favourable it is for organisms to colonise) meaning the location of the gear will affect fishing rates (Ayaz et al., 2006; Baeta et al., 2009; Stelfox et al., 2016).

Stelfox et al. (2016) reference a review looking at gillnets in the Baltic Sea. The study showed that the catch rate rapidly decreased until becoming stable at three months (at 20% of the original rate); after 27 months the rate decreased further to approximately 5 to 6% (Tschernij and Larsson, 2003). As referenced by Stelfox et al. (2016), a study of ghost-fishing gillnets on the Norwegian continental slope suggests that ghost fishing may be a more serious problem in deeper waters, presumably due to gear being less visible due to lower rates of biofouling (Humborstad et al., 2003). As nets become 'full' they will gradually sink until they reach the seafloor. Authors suggest that the biofouling and catch may be released during stormy conditions allowing it to float again, continuing fishing (Ayaz et al., 2006; Stelfox et al., 2016).

As noted above, another risk for harbour porpoise is microplastics (IAMMWG et al., 2015; Philipp et al., 2021). Microplastics may be ingested by harbour porpoise through bioaccumulation whilst feeding on demersal fish species (Philipp et al., 2021). The CSIP reports found evidence of ingestion of marine litter by harbour porpoise, with 10 individuals recorded from 2005 to 2010 (from a total of 478 post-mortems/457 identified causes of death). However, the authors concurred that this did not have a "…significant pathological impact on the animal and had no relationship to the cause of death…". As this is based on stranded animals (suitable for post-mortem), this data may not be representative for the population level (Deaville et al., 2010).

International legislation such as Annex V of the International Convention for the Prevention of Pollution from Ships 1973 includes regulations seeking to reduce and eliminate pollution from vessels (International Maritime Organization, 2019). Vessels must keep a record book of general waste for a number of different categories, including fishing gear (IMO, 2019). This pressure is therefore managed via other legislation. Furthermore, conservation advice classes the relative level of risk of impact of litter for harbour porpoise in Bristol Channel Approaches MPA and Southern North Sea MPA to be low (JNCC, 2019b, 2019c). Considering the above evidence and conservation advice, impacts cause by litter arising from fishing vessels are concluded to be low risk for harbour porpoise. From review of the information above it is unlikely that this pressure will be taken forward for site level assessments, however this will be determined on a case-by-case basis.

9.3 Summary of the effects of vessel presence on harbour porpoise

The pressures caused by fishing vessel presence have the potential to impact harbour porpoise. As such, site level assessments are required to determine whether management may be needed for MPAs protecting harbour porpoise. The pressures of most concern that need to be assessed further in site level assessments are:

- underwater (anthropogenic) noise;
- death/injury by collision;
- visual disturbance;
- contamination;
- litter.

From review of the evidence above, fishing vessels are not the main contributors of these pressures (excluding litter such as ghost gear), with ghost gear not a key pressure for harbour porpoise.

10 Levels 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, some studies based outside of the UK have been used due to limited evidence being available from UK studies. For the purposes of this review, it is assumed that impacts will be similar despite the location, however, this information is treated with caution as there are potential differences in fishing gears and conditions. Where information is lacking, evidence referring to other small cetacean species has been included. Again, as above, any such information is treated with caution due to potential differences between species.

10.1 Knowledge gaps: harbour porpoise ecology

A clearer understanding of harbour porpoise may help better understand the impacts that bottom towed gear, nets, lines, traps and fishing vessel presence may have on harbour porpoise. Increased knowledge of the abundance and distribution of harbour porpoise, including seasonal variations, as well as life history parameters could help determine the magnitude of impacts arising from anthropogenic pressures (IAMMWG, 2015). A temporal and spatial understanding of abundance and distribution is likely particularly important for understanding the risk that anthropogenic pressures may have on harbour porpoise (IAMMWG et al., 2015).

10.2 Knowledge gaps: harbour porpoise bycatch

10.2.1 Bottom towed gear, lines and traps

Limited bycatch data particularly impacts the ability to assess the potential impacts of bottom towed gear, lines and traps on harbour porpoise through the pressure of removal of non-target species (harbour porpoise bycatch). This is in part because the UK Bycatch Monitoring Programme has focused primarily on anchored (static) nets and midwater trawls due to these gear types being considered high risk to cetacean bycatch (Kingston et al., 2021). Consequently, there is limited coverage for bottom trawls, lines and traps, with data generally sourced from non-dedicated sampling days and/or opportunistic sampling.

During non-dedicated sampling, observers might not see all bycatch as the observers have different commitments than dedicated observers do (Northridge et al., 2018, 2019; Kingston et al., 2021). Care must also be taken when making conclusions from bycatch data sourced from the Data Collection Framework programme, as this programme focuses on discards of commercial fish species and, thus, the sampling protocols are not specifically designed for quantifying bycatch of protected species (Kingston et al., 2021). However, although data from non-dedicated bycatch observers or programmes has limitations, such data still provides indicative assessments of the levels of bycatch and the risk that data-limited gears (such as bottom towed gears, lines and traps) may pose to harbour porpoise (Northridge et al., 2018).

10.2.2 Midwater gear

For midwater fisheries some bycatch data is available from the UK Bycatch Monitoring Programme, with midwater trawls being observed during dedicated and non-dedicated sampling days. As well as the limitation mentioned above regarding non-dedicated sampling, several limitations are also inherent to observer data from dedicated sampling days. For example, the observers will only be able to report on animals that have been visually observed, whilst animals that have dropped out of fishing gear underwater may not be observed (Tregenza et al., 1997). Furthermore, observer programmes are limited to the specific fisheries, regions, seasons or vessels from which sampling was observed.

10.2.3 Nets and estimating population-level effects of harbour porpoise bycatch

Even though the majority of porpoise bycatch studies are in relation to anchored (static) gears, the data and methods used to assess whether bycatch from nets has population-level effects will have limitations. Three main steps are required to calculate the impact of bycatch on harbour porpoise at a population level: 1) obtaining bycatch data (for example through observer data); 2) using bycatch data to estimate total bycatch mortality from a specific fishery; and 3) comparing total bycatch levels to the population size to determining if bycatch removal may have population-level effects. Each of these stages necessitate several caveats, assumptions and limitations.

Bycatch data is predominantly sourced through observer schemes, which have inherent limitations. As mentioned above, observers can only report on animals seen (Tregenza et al., 1997); hence, observations may provide minimum bycatch estimates. Observer schemes are also limited to the fisheries observed; with small boats without space for observers having little or no coverage (Stenson, 2003; Kingston et al., 2021). Additionally, observer programmes often focus on certain areas, seasons or fisheries where bycatch risks are known to be highest, potentially leading to high-biased bycatch estimates (IAMMWG et al., 2015).

Estimating total bycatch mortality generally requires extrapolating observer data from a sample to an entire fleet or gear type based on fishing effort (Carlén and Evans, 2020). Sample size, rate and coverage, plus how overall fishing effort was calculated, can all impact estimates of total bycatch mortality (Carlén and Evans, 2020). For vessels under 12 m (i.e., without vessel monitoring system ‘VMS’ data), determining overall fishing effort can be particularly challenging (Carlén and Evans, 2020). Whilst for anchored (static) gears, data on net length and soak time is limited but could significantly impact total bycatch estimates (Kindt-Larsen et al., 2016; Carlén and Evans, 2020; Kingston et al., 2021). Observation data can also be used in statistical models to predict the number of harbour porpoise bycaught based on operational variables (such as net-length and soak time) and ecological variables (such as harbour porpoise population) (Kindt-Larsen et al., 2023). As such, estimates of total bycatch mortality will be dependent on the methods used and whether, for example, these methods account for fisheries characteristics (e.g., Kindt-Larsen et al., 2023).

Upon estimating total bycatch mortality for a fishery, bycatch rates (for example total bycatch mortality divided by population size) are generally compared to a criterion to assess whether bycatch has population-level consequences, leading to further limitations and assumptions. For example, data on population size (such as SCANS surveys; Hammond et al., 2017) is generally obtained less frequently (approximately every 10 years) than annual estimates of bycatch mortality. Therefore, as the population size is not known on year-by-year basis, a higher bycatch rate in any one year could reflect a higher mortality on a static population size or reflect lower mortality rates on an increasing population size (STECF, 2019). The spatial and temporal scales being assessed, plus the criterion selected, will also substantially impact conclusions on what equates to “acceptable” or “sustainable” levels of bycatch (ICES, 2019; STECF, 2019; Carlén and Evans, 2020).

10.3 Knowledge gaps: removal of target and non-target (prey) species

The link between harbour porpoise diet and the removal of prey by fishing effort is not fully understood. This interaction is made more challenging when considering that the diet of harbour porpoise varies with geographical location, age, sex and time of year (Santos et al., 2004; Sveegaard et al., 2012; Wisniewska et al., 2018). A limitation in diet studies of harbour porpoise is that they use stomach analysis of stranded or bycaught animals. The diet of a healthy animal may differ from a dying/sick animal and bycaught animals may prefer the species they die potentially targeting (Santos and Pierce, 2003). Additionally, the prey found in stomach contents will depend on gastric passage times. For example, often prey in stomach contents are identified through otoliths (ear bones) of fish. Consequently, there may be a bias towards detecting remains of larger prey in stomach contents, as the smaller otoliths of smaller fish will be digested quicker (Ross et al., 2016; Wisniewska, Johnson, Teilmann, Rojano-Doñate, et al., 2018).

Santos and Pierce (2003) also discussed the possibility of whether harbour porpoise could take advantage of discarded catch from fishing operations, but the only evidence referenced was for other cetacean species, so cannot be used as a proxy following advice from JNCC and NE (JNCC and NE pers. comms., 2022). Additionally, the landing obligation has been introduced since this paper was published, meaning that discards should be reduced. JNCC and NE confirm that there is a lack of evidence to confirm whether depredation on discards occurs and advised that it is highly unlikely that harbour porpoise would target dead fish (albeit harbour porpoise will feed on dead fish in captivity, Miller, 2010). Additionally, the review of literature for vessel presence (including on visual disturbance and underwater noise, section 9.1) suggests that individuals are unlikely to approach a fishing vessel directly.

If available, trends in harbour porpoise abundance could indicate whether fisheries have removed prey to an extent where porpoise populations are impacted. For example, there was no statistical support for a change in porpoise abundance in the North Sea from 1994 to 2016 (Hammond et al., 2021), which could suggest there is sufficient prey available to maintain harbour porpoise populations at present (i.e. they are able to adapt to current levels of fishing). However, SCANs surveys are approximately every 10 years and thus there are limited datapoints to detect changes in abundance over time (Hammond et al., 2021). This is particularly the case for porpoise in the Celtic and Irish Seas, where there are currently insufficient data to detect changes in population size (Hammond et al., 2021; ICES, 2021). This was also considered the case for porpoise abundance in the UK: the latest report under Article 17 on the implementation of the Habitats Directive[6] concluded that the

[6] environment.ec.europa.eu/topics/nature-and-biodiversity/habitats-directive_en

population status of harbour porpoise in the UK are unknown due to there being insufficient data points to detect a trend (JNCC, 2019a). Given the limited data on population trends, it is difficult to determine whether the current UK porpoise population represents a favourable reference population, and whether, for example, prey removal by fisheries (and/or any combination effects of anthropogenic or environmental changes) are, or have previously, affected population levels (JNCC, 2019a).

10.4 Knowledge gaps: understanding the impacts of fishing vessel presence

A fundamental limitation of assessing potential impacts of pressures from vessel presence on harbour porpoise is the difficultly in determining impacts specifically from commercial fishing vessels versus impacts arising from other vessels or activities. For example, from necropsies of stranded individuals harbour porpoise mortality has been linked to vessel strikes and contaminants (e.g., Deaville et al., 2011, 2017); however, determining the exact source of vessel strikes or contaminants is challenging. Similarly, although commercial fishing vessels may potentially impact harbour porpoise through underwater noise (e.g., Wisniewska, Johnson, Teilmann, Siebert, et al., 2018), differentiating these potential impacts from the cumulative impacts of acoustic disturbance from other vessel types (as well as other anthropogenic activities) is extremely challenging.

Determining the potential impacts of ghost gear on harbour porpoise through entanglement is also inherently challenging given the difficulties in observing such incidents at sea. Evidence on entanglement with lost or abandoned gear is predominantly confined to passive gears such as gillnets (IAMMWG et al., 2015), whilst limited information is available on transient ghost gear that follow wind and current movements (Stelfox et al., 2016). Estimates of ghost fishing rates may also be biased towards survey effort as if more time is spent surveying, the more animals are likely to be found entangled. Furthermore, causes of death are normally determined through the post-mortem of stranded animals. If the condition of the individual is not optimal or there are access issues so that these animals are not examined, the findings may not be representative for the population (Stelfox et al., 2016).

Data on vessel presence is also likely a key limitation for assessing the impacts of potential pressures. Given under 12 m vessels do not have VMS, understanding the potential impacts on harbour porpoise from the presence of smaller fishing vessels may be particularly challenging. The rollout of inshore vessel monitoring systems (I-VMS) on vessels under 12 m is underway. This will give the potential to gather vital information on the location and activity of these vessels, leading to greater evidence and an increased understanding of likely interactions, although the data is unlikely to be available in time for initial site assessments.

11 Variation in impacts

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

11.1 Factors affecting all pressures

The impacts of all fishing gears (plus fishing vessel presence), and all associated pressures on harbour porpoise will be dependent on a number of factors, particularly those associated with the fishing activity. For example, potential impacts from harbour porpoise bycatch, the removal of prey species and any physical changes to the seabed will likely strongly depend on fishing intensity (Vinther, 1999; Larsen and Vinther, 2004). The abundance and distribution of harbour porpoise relative to the spatial and seasonal overlap with the relevant fishery will also impact the extent to which specific fisheries and vessel presence impact harbour porpoise (Vinther, 1999; Larsen and Vinther, 2004).

Harbour porpoise foraging ecology and life history parameters may all influence the extent to which individuals overlap with fishing activities. Seasonal movements of harbour porpoise and seasonal variations in habitat preference (IAMMWG, 2015) may influence the overlap between harbour porpoise and fishing activity; thus, affecting the potential impacts of removing prey species. The presence of calves and juveniles might affect bycatch rates, as depending on the depth, juveniles and calves might not be able to dive as deep as adults and thus may be less likely to encounter bottom towed or bottom-anchored gears (Santos and Pierce, 2003). Given the high metabolic demands and near constant feeding rates of harbour porpoise (Wisniewska et al., 2016), individuals with particularly high energetic demands (for example reproducing or lactating females or animals in poor body condition) may be particularly vulnerable to reduced energetic intake linked to changes in prey availability (Kastelein et al., 2018). Juveniles may also feed on a different composition of prey to adults due potentially to the variation in ability to dive as deeply and needing to consume smaller prey (Santos and Pierce, 2003; Wisniewska et al., 2016, 2018; Hoekendijk et al., 2018).

Any potential impacts of fishing gears on harbour porpoise will also likely vary with (and form part of the cumulative impacts from) other external factors. A range of factors beyond fishing will cumulatively impact prey availability, such as annual changes in fish biomass and recruitment, as well as environmental drivers of fish stocks (Ransijn et al., 2019; Stalder et al., 2020). Choice of habitat use by harbour porpoise is likely to be further driven by other non-fishing related activities (for example noisy activities such as seismic activity and pile driving) (Kyhn et al., 2015; Benhemma-Le Gall et al., 2021), which could thus possibly affect spatial overlap between harbour porpoise and fisheries. As described in IAMMWG et al. (2015), the combined effect of any combination of pressures will likely have more deleterious consequences for harbour porpoise than one pressure alone.

11.2 Factors affecting harbour porpoise bycatch impacts

For all fishing gears, harbour porpoise bycatch will likely depend on factors such as fishing effort, the target fishery, and – potentially critically – the spatial and temporal overlap of the fishery relative to the distribution and abundance of harbour porpoise (e.g., Vinther, 1999; Larsen and Vinther, 2004; Herr, Fock and Siebert, 2009; Bjørge, Skern-Mauritzen and Rossman, 2013; Kindt-Larsen et al., 2023). The extent to which bycatch impacts harbour porpoise at a population level will also depend on population size. Infrequent bycatch events likely pose a low risk on a large population size, particularly if the population size is increasing (STECF, 2019). Conversely, higher bycatch rates can reflect higher mortality on a static population size or could reflect lower mortality rates on an increasing population size (STECF, 2019).

The factors affecting how bottom towed gear, line and trap fisheries might impact harbour porpoise bycatch are less clear due to limited bycatch data. The type of bottom towed gear, line or trap fishery used could potentially influence bycatch risk. However, given the lack of observational data for these more data-limited gears with regards to bycatch risk, evidence supporting variation in bycatch rates across different types of fisheries is limited.

For net fisheries (where there is more bycatch data available), bycatch may vary between different metiers, net types, fisheries and, for bottom-set nets, potentially depth (e.g., Northridge et al., 2019; ICES, 2020a). Bycatch rates may also vary with fisheries characteristics, such as net density, gillnet soak time and net length, and may also vary spatially and from year-to-year (Larsen et al., 2002; Kindt-Larsen et al., 2016, 2023; Moan et al., 2020; Kingston et al., 2021). However, harbour porpoise density and fishing effort are particularly strong predictors of bycatch levels from nets (e.g., Kindt-Larsen et al., 2016, 2023).

Another key factor influencing levels of bycatch from nets will be the use of ADDs. The UK Bycatch Monitoring Programme reports indicate that harbour porpoise bycatch rates are significantly reduced as a result of ADD use, with 83% lower bycatch rates of harbour porpoise observed between 2008 and 2018 in nets properly equipped with ADDs (Northridge et al., 2018). In 2019, estimated UK harbour porpoise bycatch from net fisheries was approximately 830 individuals assuming full ADD compliance and 1,060 assuming no ADD use (albeit the scenario of ‘full ADD compliance’ uses no-ADD bycatch rates for four net metiers due to these metiers mainly involving under 12 m vessels) (Kingston et al., 2021). There are, however, concerns over vessels not putting ADDs on nets with optimal spacing between devices (Kingston et al., 2021). Additionally, a large proportion of the UK gillnet fleet consists of vessels under 12 m, for which the use of ADDs is not mandatory but from which significant bycatch may occur (IAMMWG et al., 2015). Nevertheless, overall bycatch estimates suggests that ADD use reduces – but does not eliminate - harbour porpoise mortality (Kingston et al., 2021). This is also supported by evidence from North America, where ADDs can reduce bycatch of small cetaceans from gillnet fisheries when used appropriately (Dawson et al., 2013).

11.3 Factors affecting impacts of physical loss, change or damage to supporting habitat

Physical impacts of bottom towed gear on the seabed (and subsequently potential impacts to prey species) will also likely vary with factors, such as fishing intensity, history of prior fishing, gear type (and associated penetration depth), and habitat type (Hiddink et al., 2017; Sciberras et al., 2018; Rijnsdorp et al., 2020). For further details, please see the literature reviews on Stage 3 Fishing Gear Impacts Evidence documents[3] for anchored nets and lines, traps, and bottom towed gear.

11.4 Factors affecting vessel presence impacts

There are a number of specific variables that may affect the extent that pressures associated with vessel presence will impact harbour porpoise.

The potential impacts arising from underwater noise and visual disturbance from fishing vessels may vary with factors associated with the vessels, the local environment and harbour porpoise ecology. For example, faster moving and larger vessels will produce higher noise levels (Hermannsen et al., 2014; Erbe et al., 2019) and vessels that move more erratically may pose higher disturbance risk to small cetaceans than slower moving or stationary vessels (Pirotta et al., 2015). The density of vessel presence and type of fishing gear (including noise generated by bottom towed gear on the seabed) will also impact acoustic disturbance by commercial fishing vessels (Heinänen and Skov, 2015; Daly and White, 2021). The topography of the seabed may also drive impacts, with sloping topography having the potential to channel noise effects (Daly and White, 2021). Individuals with particularly high energetic demands (such as reproducing or lactating females or animals in poor body condition) may be especially vulnerable to disrupted foraging behaviour as a result of acoustic or visual disturbance (Wisniewska et al., 2016). Habituation to disturbance, social context (for example group size and the presence of calves) and behavioural context at the time of a disturbance may also influence any potential impacts of visual and/or acoustic disturbance from vessel presence on harbour porpoise (Oakley et al., 2017).

Collision risk could vary with several factors. For example, faster and more erratic moving vessels may pose a higher risk of causing vessel strikes (IAMMWG et al., 2015), whilst individuals exhibiting near-surface behaviour at the time of vessel presence may be at higher risk of being struck (Schoeman et al., 2020). There may also be higher collision risk higher in areas where there is spatial and temporal overlap between high densities of vessels and harbour porpoise.

Any impacts from contaminants will likely vary depending on geographical location. For example, it is assumed that any contaminants from terrestrial sources will remain nearer inshore closer to their source as they will settle out. As previously noted, finer sediments also have a greater ability to trap contaminants and are more easily resuspended/disperse when disturbed during interaction with fishing gear. Vessels larger than 45 m (ships and industrial fishing vessels) do not appear to have the same controls, for example on ballast water discharge meaning this pathway is higher risk, so transit routes to ports/harbours may show higher levels; however, such larger fishing vessels are assumed to fish further offshore and in deeper waters. As previously described the level of contaminants in harbour porpoise through ingestion of contaminated prey and bioaccumulation may vary depending on the age, sex and generation of the animal (IAMMWG et al., 2015; van den Heuvel-Greve et al., 2021).

The extent to which all pressures associated with vessel presence impact harbour porpoise will also be influenced by (and combine with) the cumulative impacts of other external factors. For example, the impacts of visual and acoustic disturbance from fishing vessels, will combine with noise and visual disturbance from other activities, such as pile driving and offshore windfarms. Such external anthropogenic activities will in-turn contribute to behaviour disturbance and habitat displacement (e.g., Benhemma-Le Gall et al., 2021).

12 Document summary

For each MPA protecting harbour porpoise, 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. This assessment 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 harbour porpoise in MPAs. Examples of wider management measures are summarised below:

- Domestic legislation and requirements, such as Regulation (EU) 2019/1241 (ADD requirements)[7];

[7] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32019R1241

- Quota management for commercial fish species;
- Control measures for the size/types of gears; and
- Domestic initiatives, such as the UK Bycatch Mitigation Initiative (DEFRA, 2022).

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 harbour porpoise

This annex summarises the pressures that may be exerted by on harbour porpoise. The classification of pressures, the determination of which pressures to consider and Tables A1.1 to A1.7 are based on advice from, and liaison with, JNCC and Natural England, as well as the Advice on Operations (AoO) for Bristol Channel Approaches MPA and the Southern North Sea MPA (JNCC, 2019c, 2019b).

Table A1.1 summarises all pressures that may be exerted by each gear type (bottom towed gear, nets – included anchored and non-anchored, traps, lines and midwater gear) plus fishing vessel presence on harbour porpoise. Pressures were classified as one of the following:

- **Key pressures (KP)** = Identified as a key pressure affecting harbour porpoise and therefore considered within this document.
- **Considered (C) pressures** = Identified as a pressure that may impact harbour porpoise and therefore is considered within this document.
- **Vessel presence (VP) pressures** = Identified as a pressure that is relevant to more than one gear type and therefore is considered within the 'vessel presence' section of this document (section 9).
- **Not considered (NC) pressures =** Identified as a potential pressure that may impact harbour porpoise, but due to insufficient evidence on the mechanism for impact, this pressure was not considered within this document. These interactions will be considered at the time of site level assessments (where appropriate) using the best-available evidence relevant to the activity in question and take into consideration any known condition issues or further advice received from JNCC or Natural England.

Tables A1.2 to A1.7 list the pressures for individual gear types (plus fishing vessel presence) that may affect harbour porpoise, their prey species and/or the supporting habitat(s), plus the relative level of risk of impact of such pressures. These tables also include justification text for why pressures were either considered within this document (KP, C and VP pressures) or were not considered within this document (NC pressures).

Table A1. 1. Summary of the key pressures for harbour porpoise by different fishing gear types. Pressures considered further are marked in red, and those not considered are marked in white.

Potential Pressure	Fishing gear type					
	Bottom towed gear	Anchored nets	Non-anchored nets	Traps	Lines	Midwater gear
Abrasion or disturbance of the substrate on the surface of the seabed	C	C	NC	C	C	NC
Barrier to species movement	NC	NC	NC	NC	NC	NC
Changes in suspended solids (water clarity)	C	C	NC	C	C	NC
Death or injury by collision	VP	VP	VP	VP	VP	VP
Deoxygenation	NC	NC	NC	NC	NC	NC
Hydrocarbon and PAH contamination	VP	VP	VP	VP	VP	VP
Introduction of light	NC	NC	NC	NC	NC	NC
Introduction of microbial pathogens	NC	NC	NC	NC	NC	NC
Introduction or spread of invasive non-indigenous species	NC	NC	NC	NC	NC	NC
Litter	VP	VP	VP	VP	VP	VP
Nutrient enrichment	NC	NC	NC	NC	NC	NC
Organic enrichment	NC	NC	NC	NC	NC	NC
Penetration and/or disturbance of the substrate below the surface of the seabed, including abrasion	C	C	NC	C	C	NC
Physical change (to another seabed type)	C	C	NC	C	C	NC
Physical change (to another sediment type)	C	C	NC	C	C	NC
Removal of non-target species	KP	KP	KP	KP	KP	KP
Removal of target species	KP	KP	KP	KP	KP	KP
Smothering and siltation rate changes (Light)	C	C	NC	C	C	NC
Synthetic compound contamination	VP	VP	VP	VP	VP	VP
Transition elements and organo-metal contamination	VP	VP	VP	VP	VP	VP
Underwater noise changes	VP	VP/C*	VP/C*	VP	VP	VP
Visual disturbance	VP	VP	VP	VP	VP	VP

***** *= considered within this review in relation to ADDs associated with gill nets.*

Table A1. 2. Summary of the pressures exerted by bottom towed gear on harbour porpoise. Pressures considered within this document for bottom towed gear are marked in red. Pressures not considered further in this document for bottom towed gear are marked in white.

Potential Pressure		Justification
Direct	Removal of non-target species (harbour porpoise bycatch)	Harbour porpoise bycatch in fishing gears has been identified by JNCC and NE as a key pressure effecting harbour porpoise populations in the UK. Though predominantly associated with static nets, the mechanism exists for this pressure to occur in bottom towed gear and this pressure will therefore be considered further for these gears.
Direct	Underwater noise (including vibration)	Underwater noise has been identified by JNCC and NE as a key pressure causing disturbance of harbour porpoise. While the impact of noise disturbance from boat transit and fishing gear deployment and retrieval is likely to be low compared with other activities, limited information is available to corroborate this. This pressure will therefore be considered further within the ‘vessel presence’ review.
Direct	Visual disturbance	While the impact of visual disturbance caused by individual vessels is likely to be low, this may increase with scale, intensity and proximity of vessel activity. This pressure will therefore be considered further within the ‘vessel presence’ review.
Direct	Death or injury by collision	While the occurrence of this pressure caused by individual vessels is likely to be low, this may increase with scale, intensity and proximity of vessel activity. This pressure will therefore be considered further within the ‘vessel presence’ review.
Direct	Barrier to species movement	JNCC and NE advise there is insufficient evidence of/ mechanism for impact. Therefore, this pressure will not be considered further.
Indirect	Removal of target and non-target prey species	Removal of prey species has been identified by JNCC and NE as a key pressure effecting harbour porpoise populations in the UK. This pressure will therefore be considered further in this review.
Indirect	Physical change (to another seabed/sediment type)	These pressures, associated with bottom towed gear, may impact the supporting habitat for harbour porpoise and will therefore be considered briefly in this review under 'Physical loss, change or damage to supporting habitat' with links to more detailed reviews.
Indirect	Abrasion/disturbance to surface substrate	
Indirect	Penetration and/or disturbance of the substrate below the surface of the seabed	
Indirect	Changes in suspended solids (water clarity)	
Indirect	Smothering/siltation rate changes (light)	
Indirect	Nutrient enrichment	JNCC and NE advise there is insufficient evidence of/ mechanism for impact. Therefore, this pressure will not be considered further.
Indirect	Deoxygenation	
Indirect	Organic enrichment	
Direct/ Indirect	Litter	While not considered a key pressure, bycatch/entanglement in ghost gears and ingestion of plastics can impact harbour porpoise populations. As the mechanism exists for this pressure to occur in bottom towed gears, this will be considered further within the ‘vessel presence’ review.

	Hydrocarbon and 'PAH' Polycyclic Aromatic Hydrocarbon contamination	These pressures are more relevant to the presence of fishing vessels than the fishing gear itself, please see the fishing vessel presence table.
	Transition elements and organo-metal (for exmaple Tributyltin 'TBT') contamination	
	Synthetic compound contamination (incl. pesticides, antifoulants, pharmaceuticals)	
	Introduction of microbial pathogens	JNCC and NE advise there is insufficient evidence of/ mechanism for impact. Therefore, this pressure will not be considered further.
	Introduction or spread of invasive non-indigenous species (INIS)	JNCC and NE advise there is insufficient evidence of/ mechanism for impact. Therefore, this pressure will not be considered further.
	Introduction of light	JNCC and NE advise there is insufficient evidence of/ mechanism for impact. Therefore, this pressure will not be considered further.

Table A1. 3. Summary of the pressures exerted by nets on harbour porpoise. Pressures considered within this document for nets are marked in red. Pressures not considered further in this document for nets are marked in white.

Potential Pressure		Justification	
		Anchored (set) nets	Non-anchored nets (drift nets)
Direct	Removal of non-target (bycatch) species	Harbour porpoise bycatch in fishing gears has been identified by JNCC and NE as a key pressure effecting harbour porpoise populations in the UK. This pressure is predominantly associated with static nets and will therefore be considered further for these gears.	
	Underwater noise (including vibration) - fishing vessel/operations	Underwater noise has been identified by JNCC and NE as a key pressure causing disturbance of harbour porpoise. While the impact of noise disturbance from boat transit and fishing gear deployment and retrieval is likely to be low compared with other activities, limited information is available to corroborate this. This pressure will therefore be considered further within the 'vessel presence' review.	
	Underwater noise - ADDs	ADD use, associated with gillnets, can cause disturbance to harbour porpoise. The impact of this pressure is likely to increase with scale, intensity, and proximity of ADD use. This pressure will therefore be considered further for these gears.	Non-anchored nets are not associated with ADD use. Therefore, this specific type of underwater noise pressure will not be considered further.
	Visual disturbance	While the impact of visual disturbance caused by individual vessels is likely to be low, this may increase with scale, intensity and proximity of vessel activity. This pressure will therefore be considered further under the 'vessel presence' review.	
	Death or injury by collision	While the occurrence of this pressure caused by individual vessels is likely to be low, this may increase with scale, intensity and proximity of vessel activity. This pressure will	

<table>
<tr><td rowspan="2"></td><td></td><td colspan="2">therefore be considered further under the ‘vessel presence’ review.</td></tr>
<tr><td>Barrier to species movement</td><td colspan="2">JNCC and NE advise there is insufficient evidence of/ mechanism for impact. Therefore, this pressure will not be considered further.</td></tr>
<tr><td rowspan="9">Indirect</td><td>Removal of target and non-target prey species</td><td colspan="2">Removal of prey species has been identified by JNCC and NE as a key pressure effecting harbour porpoise populations in the UK. This pressure will therefore be considered further for these gears.</td></tr>
<tr><td>Physical change (to another seabed and/or sediment type)</td><td rowspan="5">These pressures, associated with anchored nets, may impact the supporting habitat for harbour porpoise and will therefore be considered briefly in this literature review under 'Physical loss, change or damage to supporting habitat' with links to more detailed reviews.</td><td rowspan="5">JNCC and NE advise there is insufficient evidence of/ mechanism for impact. Therefore, this pressure will not be considered further.</td></tr>
<tr><td>Abrasion/disturbance to surface substrate</td></tr>
<tr><td>Penetration and/or disturbance of the substrate below the surface of the seabed</td></tr>
<tr><td>Changes in suspended solids (water clarity)</td></tr>
<tr><td>Smothering/siltation rate changes (light)</td></tr>
<tr><td>Nutrient enrichment</td><td colspan="2" rowspan="3">JNCC and NE advise there is insufficient evidence of/ mechanism for impact. Therefore, this pressure will not be considered further.</td></tr>
<tr><td>Deoxygenation</td></tr>
<tr><td>Organic enrichment</td></tr>
<tr><td rowspan="7">Direct/ Indirect</td><td>Litter</td><td colspan="2">While not considered a key pressure, bycatch/entanglement in ghost gears and ingestion of plastics can impact harbour porpoise populations. As the mechanism exists for this pressure to occur in net fisheries, this will be considered further within the ‘vessel presence’ review.</td></tr>
<tr><td>Hydrocarbon and PAH contamination</td><td colspan="2" rowspan="3">These pressures are more relevant to the presence of fishing vessels than the fishing gear itself, please see the fishing vessel presence table.</td></tr>
<tr><td>Transition elements and organo-metal (e.g. TBT) contamination</td></tr>
<tr><td>Synthetic compound contamination (incl. pesticides, antifoulants, pharmaceuticals)</td></tr>
<tr><td>Introduction of microbial pathogens</td><td colspan="2">JNCC and NE advise there is insufficient evidence of/ mechanism for impact. Therefore this pressure will not be considered further.</td></tr>
<tr><td>Introduction or spread of invasive non-indigenous species (INIS)</td><td colspan="2">JNCC and NE advise there is insufficient evidence of/ mechanism for impact. Therefore, this pressure will not be considered further.</td></tr>
<tr><td>Introduction of light</td><td colspan="2">JNCC and NE advise there is insufficient evidence of/ mechanism for impact. Therefore, this pressure will not be considered further.</td></tr>
</table>

Table A1. 4. Summary of the pressures exerted by lines on harbour porpoise. Pressures considered within this document for lines are marked in red. Pressures not considered further in this document for lines are marked in white.

Potential Pressure		Justification
Direct	Removal of non-target (bycatch) species	Harbour porpoise bycatch in fishing gears has been identified by JNCC and NE as a key pressure effecting harbour porpoise populations in the UK. Though predominantly associated with static nets, the mechanism exists for this pressure to occur in lines and this pressure will therefore be considered further for these gears.
	Underwater noise (including vibration)	Underwater noise has been identified by JNCC and NE as a key pressure causing disturbance of harbour porpoise. While the impact of noise disturbance from boat transit and fishing gear deployment and retrieval is likely to be low compared with other activities, limited information is available to corroborate this. This pressure will therefore be considered further within the 'vessel presence' review.
	Visual disturbance	While the impact of visual disturbance caused by individual vessels is likely to be low, this may increase with scale, intensity, and proximity of vessel activity. This pressure will therefore be considered further under the 'vessel presence' review.
	Death or injury by collision	While the occurrence of this pressure caused by individual vessels is likely to be low, this may increase with scale, intensity and proximity of vessel activity. This pressure will therefore be considered further within the 'vessel presence' review.
	Barrier to species movement	JNCC and NE advise there is insufficient evidence of/ mechanism for impact. Therefore, this pressure will not be considered further.
Indirect	Removal of target and non-target prey species	Removal of prey species has been identified by JNCC and NE as a key pressure effecting harbour porpoise populations in the UK. This pressure will therefore be considered further for these gears.
	Physical change (to another seabed and/or sediment type)	While not considered a key pressure, bottom set lines can be anchored/weighed to keep them in place. This may impact the supporting habitat for harbour porpoise and will therefore be considered briefly in this literature review under 'Physical loss, change or damage to supporting habitat' with links to more detailed reviews.
	Abrasion/disturbance to surface substrate	
	Penetration and/or disturbance of the substrate below the surface of the seabed	
	Changes in suspended solids (water clarity)	
	Smothering/siltation rate changes (light)	
	Nutrient enrichment	JNCC and NE advise there is insufficient evidence of/ mechanism for impact. Therefore, this pressure will not be considered further.
	Deoxygenation	
	Organic enrichment	
Direct/ Indirect	Litter	While not considered a key pressure, bycatch/entanglement in ghost gears and ingestion of plastics can impact harbour porpoise populations. As the mechanism exists for this pressure to occur in line fisheries, this will be considered further within the 'vessel presence' review
	Hydrocarbon and PAH contamination	

	Transition elements and organo-metal (for example TBT) contamination	These pressures are more relevant to the presence of fishing vessels than the fishing gear itself, please see the fishing vessel presence table.
	Synthetic compound contamination (incl. pesticides, antifoulants, pharmaceuticals)	
	Introduction of microbial pathogens	JNCC and NE advise there is insufficient evidence of/ mechanism for impact. Therefore, this pressure will not be considered further.
	Introduction or spread of invasive non-indigenous species (INIS)	JNCC and NE advise there is insufficient evidence of/ mechanism for impact. Therefore, this pressure will not be considered further.
	Introduction of light	JNCC and NE advise there is insufficient evidence of/ mechanism for impact. Therefore, this pressure will not be considered further.

Table A1. 5. Summary of the pressures exerted by traps on harbour porpoise. Pressures considered within this document for traps are marked in red. Pressures not considered further in this document for traps are marked in white.

Potential Pressure		Justification
Direct	Removal of non-target (bycatch) species	Harbour porpoise bycatch in fishing gears has been identified by JNCC and NE as a key pressure effecting harbour porpoise populations in the UK. Though predominantly associated with static nets, the mechanism exists for this pressure to occur in traps and this pressure will therefore be considered further for these gears.
	Underwater noise (including vibration)	Underwater noise has been identified by JNCC and NE as a key pressure causing disturbance of harbour porpoise. While the impact of noise disturbance from boat transit and fishing gear deployment and retrieval is likely to be low compared with other activities, limited information is available to corroborate this. This pressure will therefore be considered further within the 'vessel presence' review.
	Visual disturbance	While the impact of visual disturbance caused by individual vessels is likely to be low, this may increase with scale, intensity, and proximity of vessel activity. This pressure will therefore be considered further under the 'vessel presence' review.
	Death or injury by collision	While the occurrence of this pressure caused by individual vessels is likely to be low, this may increase with scale, intensity and proximity of vessel activity. This pressure will therefore be considered further within the 'vessel presence' review.
	Barrier to species movement	JNCC and NE advise there is insufficient evidence of/ mechanism for impact. Therefore this pressure will not be considered further.
Indirect	Removal of target and non-target prey species	Removal of prey species has been identified by JNCC and NE as a key pressure effecting harbour porpoise populations in the UK. This pressure will therefore be considered further for these gears.
	Physical change (to another seabed and/or sediment type)	These pressures, associated with traps, may impact the supporting habitat for harbour porpoise and will therefore be considered briefly in this literature review under 'Physical

	Abrasion/disturbance to surface substrate	loss, change or damage to supporting habitat' with links to more detailed reviews.
	Penetration and/or disturbance of the substrate below the surface of the seabed	
	Changes in suspended solids (water clarity)	
	Smothering/siltation rate changes (light)	
	Nutrient enrichment	JNCC and NE advise there is insufficient evidence of/ mechanism for impact. Therefore this pressure will not be considered further.
	Deoxygenation	
	Organic enrichment	
Direct/ Indirect	Litter	While not considered a key pressure, bycatch/entanglement in ghost gears and ingestion of plastics can impact Harbour porpoise populations. As the mechanism exists for this pressure to occur in trap fisheries, this will be considered further within the 'vessel presence' review.
	Hydrocarbon and PAH contamination	These pressures are more relevant to the presence of fishing vessels than the fishing gear itself, please see the fishing vessel presence table.
	Transition elements and organo-metal (e.g. TBT) contamination	
	Synthetic compound contamination (incl. pesticides, antifoulants, pharmaceuticals)	
	Introduction of microbial pathogens	JNCC and NE advise there is insufficient evidence of/ mechanism for impact. Therefore, this pressure will not be considered further.
	Introduction or spread of invasive non-indigenous species (INIS)	JNCC and NE advise there is insufficient evidence of/ mechanism for impact. Therefore, this pressure will not be considered further.
	Introduction of light	JNCC and NE advise there is insufficient evidence of/ mechanism for impact. Therefore, this pressure will not be considered further.

Table A1. 6. Summary of the pressures exerted by midwater gear on harbour porpoise. Pressures considered within this document for midwater gear are marked in red. Pressures not considered further in this document for midwater gear are marked in white.

Potential Pressure		Justification
Direct	Removal of non-target (bycatch) species	Harbour porpoise bycatch in fishing gears has been identified by JNCC and NE as a key pressure effecting harbour porpoise populations in the UK. Though predominantly associated with static nets, the mechanism exists for this pressure to occur in midwater gears and this pressure will therefore be considered further for these gears.
	Underwater noise (including vibration)	Underwater noise has been identified by JNCC and NE as a key pressure causing disturbance of harbour porpoise. While the impact of noise disturbance from boat transit and fishing gear deployment and retrieval is likely to be low compared with other activities, limited information is available to corroborate this. This pressure will therefore be considered further within the ‘vessel presence’ review.
	Visual disturbance	While the impact of visual disturbance caused by individual vessels is likely to be low, this may increase with scale, intensity, and proximity of vessel activity. This pressure will therefore be considered further under the ‘vessel presence’ review.
	Death or injury by collision	While the occurrence of this pressure caused by individual vessels is likely to be low, this may increase with scale, intensity and proximity of vessel activity. This pressure will therefore be considered further within the ‘vessel presence’ review.
	Barrier to species movement	JNCC and NE advise there is insufficient evidence of/ mechanism for impact. Therefore this pressure will not be considered further.
Indirect	Removal of target and non-target prey species	Removal of prey species has been identified by JNCC and NE as a key pressure effecting harbour porpoise populations in the UK. This pressure will therefore be considered further for these gears.
	Physical change (to another seabed and/or sediment type)	JNCC and NE advise there is insufficient evidence of/ mechanism for impact. Therefore this pressure will not be considered further.
	Abrasion/disturbance to surface substrate	
	Penetration and/or disturbance of the substrate below the surface of the seabed	
	Changes in suspended solids (water clarity)	
	Smothering/siltation rate changes (light)	
	Nutrient enrichment	JNCC and NE advise there is insufficient evidence of/ mechanism for impact. Therefore this pressure will not be considered further.
	Deoxygenation	
	Organic enrichment	
Direct/ Indirect	Litter	While not considered a key pressure, bycatch/entanglement in ghost gears and ingestion of plastics can impact harbour porpoise populations. As the mechanism exists for this pressure to occur in midwater fisheries, this will be considered further within the ‘vessel presence’ review.

	Hydrocarbon and PAH contamination	These pressures are more relevant to the presence of fishing vessels than the fishing gear itself, please see the fishing vessel presence table.
	Transition elements and organo-metal (e.g. TBT) contamination	
	Synthetic compound contamination (incl. pesticides, antifoulants, pharmaceuticals)	
	Introduction of microbial pathogens	JNCC and NE advise there is insufficient evidence of/ mechanism for impact. Therefore, this pressure will not be considered further.
	Introduction or spread of invasive non-indigenous species (INIS)	JNCC and NE advise there is insufficient evidence of/ mechanism for impact. Therefore, this pressure will not be considered further.
	Introduction of light	JNCC and NE advise there is insufficient evidence of/ mechanism for impact. Therefore, this pressure will not be considered further.

Table A1. 7. Summary of the pressures exerted by fishing vessel presence on harbour porpoise. Pressures considered within this document for fishing vessel presence are marked in red. Pressures not considered further in this document for fishing vessel presence are marked in white.

Potential Pressure		Justification
Direct	Underwater noise (including vibration)	Underwater noise has been identified by JNCC and NE as a key pressure causing disturbance of harbour porpoise. While the impact of noise disturbance from boat transit and fishing gear deployment and retrieval is likely to be low compared to other activities, limited information is available to corroborate this. This pressure will therefore be considered further in this review.
	Death or injury by collision	While the occurrence of this pressure caused by individual vessels is likely to be low, this may increase with scale, intensity, and proximity of vessel activity. This pressure will therefore be considered further under this review.
	Visual disturbance	While the impact of visual disturbance caused by individual vessels is likely to be low, this may increase with scale, intensity, and proximity of vessel activity. This pressure will therefore be considered further within this review.
Direct/ Indirect	Litter	While not considered a key pressure, bycatch/entanglement in ghost gears and ingestion of plastics can impact harbour porpoise populations. As the mechanism exists for this pressure to occur in line fisheries, this will be considered further within this review.
	Hydrocarbon and polycyclic aromatic hydrocarbon (PAH) contamination	Impacts from contaminants have been identified by JNCC and NE as a key concern for harbour porpoise populations in the UK. While the level at which fishing vessels are likely to exert these pressures is thought to be low, this may increase with the scale and intensity of activity. This pressure will therefore be considered further within this review.
	Transition elements and organo-metal (e.g. tributyltin 'TBT') contamination	
	Synthetic compound contamination (incl. pesticides, antifoulants, pharmaceuticals)	