# Work package 10 – case studies on species and habitats

# 1. Harbour Porpoise – Full Case Study

Whilst harbour porpoises are the most common cetacean species in the North East Atlantic1 the most abundant species of whale and dolphin in UK waters2, this species is highly endangered elsewhere and is very vulnerable to disturbance, pollution and loss of food sources2. They are currently categorised as Least Concern globally by IUCN ,but the Baltic population is categorised as Critically Endangered and the Black Sea subspecies as Endangered3. Although populations in UK waters are thought to be stable4, they are present in much lower numbers than those recorded 25-30 years ago.

Whilst less well-known than other species of cetacean they have a very important ecological role. They feed mainly on fish, particularly sandeels, herring, sprats, whiting and other gadoid fish1,5 and they can also eat cephalopods like squid and octopus when available5. They live on average for around 12-15 years and have been recorded up to 20 years old in the UK and 24 elsewhere2. They become sexually mature at around 5 years of age6 and keep growing until they are around 8 years of age7. Individual porpoises can be highly mobile – for example one study of porpoises tagged in Denmark showed some individuals travelling as far as Shetland and Sweden, whilst another Danish study showed some individuals didn’t move far at all and remained in shallow waters2. Another tagging study in Greenland showed that harbour porpoises could also be long-range oceanic travelers, covering large areas of the North Atlantic, from not far west of Irish waters across to Canada and diving to depths of over 400m8.

Whilst Special Areas of Conservation (SAC) have been designated specifically to protect harbour porpoise, these areas are not protected from oil and gas development. A good example of this is the Southern North Sea SAC which is already developed for offshore fossil fuel extraction9 and is in a region being promoted for development in the latest licensing round10.

**Pollution**

In terms of direct impacts of oil and gas developments, harbour porpoise are particularly vulnerable to major oil spills because as mammals they have to come to the surface to breath every 5 minutes or so. Their blow-holes on the top of their body can easily be contaminated by oil, toxic vapours and other pollutants from the surface11. Site fidelity shown by some populations and individuals of harbour porpoises also makes them more vulnerable to oil spills, as they are less likely to move to other feeding grounds after a pollution event11. If harbour porpoises continued to feed in oil-contaminated grounds then they could experience severe pollution impacts to their respiratory systems as an immediate result of the pollution and ongoing issues as the pollution persisted. Disturbance from a clean-up operation could also be significant11.

Harbour porpoises are also susceptible to chronic pollution, particularly to bio-accumulating toxins, also known as persistent organic pollutants (POPs) such as Polycyclic Aromatic Hydrocarbons (PAHs) and polybrominated biphenyls (PCBs)2, both of which are linked to marine industry. These toxins accumulate up the food chain and are highest in the top predators, which include harbour porpoises in UK waters. They which build up in the blubber and can reduce health, nutrition, growth and fecundity.

PAHs have been shown to be present in the blubber of UK harbour porpoises12 but do not seem to accumulate as much as in other species, with similar concentration present in animals of a wide range of ages which is thought to be because this species have an enzyme system which can break down PAHs13.

Reproduction issues in UK porpoise populations have been linked to PCB levels14. It has been found that PCBs were very likely to be passed to harbour porpoise calves as they feed from their mothers. The combination of contaminants passed to the calves were particularly potent as neurotoxins and likely to impact on the development of the juveniles15.

Harbour porpoises are also impacted by plastic pollution, with plastics being found in the stomachs of stranded animals16 and they are also at risk from tangling in plastic marine litter.

**Noise and other disturbance**

Harbour porpoises are vulnerable to disturbance and other impacts from noise pollution, both the sudden loud noises associated with seismic surveys and piledriving for offshore developments (impulsive sound) and also continuous low-level sound, such as that from from shipping. Physical damage has been found in the auditory system of harbour porpoises following exposure to construction-related noise17,18 but most evidence of impacts comes from behavioural observations.

A recent study of the impact of the construction of a new offshore gas platform in the Dogger Bank on harbour porpoises found that levels of porpoise activity returned to pre-construction levels after 5 months19 . Whilst this study seems to show that there were no long-term impacts on porpoise activity as a result of construction it also highlights that impacts are still much more long-term than usually considered in EIAs19. This study highlights a key issue with many of the oil and gas related impacts on harbour porpoises, in that they are usually sub-lethal so are difficult to measure but the wider ecosystem impacts may be significant.

In an experiment looking at the impact of seismic in the southern North Sea, seismic activity did change the behaviour of sand eels, an important prey species for harbour porpoise2. Landing data also showed a temporary drop in catches of sand eels by Norwegian fishing vessels after seismic activity near their fishing grounds20.

Various other studies of seismic impacts on harbour porpoises have shown avoidance from the immediate area21 to several kilometres away22–25, over 20 kilometres26,27 and in one study over a 2,000 km2 area23. It should be remembered that when a harbour porpoise is displaced it may be moving away from the most efficient feeding grounds, it may be changing its social interactions and it may be experiencing stress responses which could all impact on its health and reproductive capacity. Indeed, a number of studies have also found evidence of changes in communication as a result of seismic survey, including reduction in buzzing behaviour (used for prey capture) up to 25km away from the source of the noise24, and a reduction in echolocation between 8-12km from the source25.

Other recorded impacts of disturbance related to oil and gas developments on harbour porpoises includes the reported death of over 2000 harbour porpoises as a result of an explosion on a gas-drilling platform in the Azoz Sea in 1982 but a primary source for this couldn’t be found28.

**Impacts on food sources**

As well as foraging behaviour being impacted by seismic surveys22,harbour porpoise are also vulnerable to shortages in their prey species which can occur when they are displaced by disturbances, or from longer impacts like climate change. Because harbour porpoise have a high metabolic rate, they are unable to cope with prolonged starvation24. Impacts on their feeding and prey availability can cause reduction in their warming blubber, impacts to their health and ability to reproduce and in the worst-case scenario, death. High energy prey species like herring and sand eel have declined in recent years which has led to an increased reliance on lower energy prey species. One study found that in years when there were less sandeels available, more harbour porpoises found stranded had died of starvation29 but this comparison, based on small sample sizes was challenged30.

Offshore habitat creation on oil and gas developments have been reported to bring some benefits to harbour porpoise by attracting higher concentrations of fish prey and acting as de facto Marine Protected Areas31

Because harbour porpoise are numerous and have an important ecological role1 , these multiple impacts don’t just affect this fascinating creature, but create a cascading effect on the whole ecosystem.

## **Harbour Porpoise: Summary table**

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| **Species** | **Harbour porpoise** |
| **Ecological importance** | High ecological importance in UK ecosystems – top predator, most common cetacean in UK waters2. |
| **Key life history traits** | Relatively early maturing for a cetacean. Can be highly mobile/migratory or show some site fidelity. Depends on sandeels, herring and other small fish2. |
| **Conservation status** | Protected under UK legislation (& EU Habitats and Species Directive)2. On OSPAR list of threatened and declining species32. IUCN – Least Concern (BUT Endangered/Critically Endangered elsewhere)14 |
| **Climate solution value** | With natural mortality offshore, harbour porpoises can contribute to blue carbon (in the same way that whales and large fish can)33. Predators also have ecosystem health and blue carbon value34. |
| **Main oil and gas impacts** |  |
| **Noise** | Can respond to construction and seismic survey noise with dramatic changes in movement and behaviour24. Can take months to return to normal activity after intense period of noise23.Can suffer permanent injury and impairment from acute noise17,18. |
| **Pollution** | Susceptible to surface oil pollution because of frequent need to surface to breathe11.  Susceptible to chronic pollution too and accumulates organic toxins in body and can pass them to young via milk35. Risk of accumulating and passing on neurotoxins. |
| **Climate change impacts** | Climate change impacts on prey species e.g. cod, sandeels may impact their fitness29. |
| **Plastic pollution** | Accidental ingestion of plastics and tangling in plastic marine litter16. |
| **Specific areas of concern/example of conflict** | Southern North Sea Special Area of Conservation – specifically designated for harbour porpoise9 but subject to existing and proposed oil and gas. developments9, including Southern North Sea cluster promoted in latest round10. |

# 2. Ocean quahog – Full Case Study

The ocean quahog is a bivalve mollusc found from the lower shore down to depths of around 500m. It is usually found buried or partly buried in sand or gravel substrates36. This species is best known for its remarkable longevity. One Icelandic specimen was found to be 507 years old, making them the longest lived non-colonial animal37. Their great age and the fact that they lay down annual growth rings which provide information about the environment in which they were living makes them extremely useful in the study of environmental history and the science of climate change38. For example the shells of ocean quahog in the Atlantic have been used to evidence historic tipping points in the ocean in the 14th century when the influx of freshwater from melting ice sheets led to a weakening of ocean currents39. This work holds a warning for our current situation where man-made global warming is leading to the melting of ice sheets and the influx of freshwater which could create a tipping point plunging the planet into a period of rapid change. Ocean quahog shells have also been used to study recruitment of herring in the North Sea over the past 455 years40.

The ocean quahog is a northern species at the southern-most extent of its range in the North Sea and not extending all the way south. It is sensitive to temperature increases and low recruitment may occur as a result of high temperatures, amongst other factors41.

In England and Wales the ocean quahog is a protected Feature of Conservation Importance 42 used in the designation of Marine Protected Areas43. It is also a Species of Principal Importance in Wales and a Priority Marine Feature in Scotland36

**Habitat loss**

Habitat loss in one of the main threats from offshore oil and gas development. Habitat is lost in the immediate footprint of a drill platform and other infrastructure but suitable habitat is also lost as a result of smothering or burial by drill waste. The quahogs’ slow growth, time taken to reach maturity and longevity all contribute to making this species vulnerable to anthropogenic impacts and the estimated regeneration time for the ocean quahog to be 83 years44. Such slow growth and reproduction mean that this species is very slow to recover from any impacts. If a population is significantly reduced, for example because of habitat loss within an oil and gas development footprint or as a result of a pollution incident then a study of North Sea ocean quahogs concluded that recovery will take more than a decade and maybe over 25 years42.

**Pollution**

Ocean quahog are filter feeders, processing large volumes of sea water every day. They are therefore susceptible to pollution extracted from the water which builds up in their tissues. Because they are so long-lived, every low concentrations of toxic chemicals can build up to more problematic levels of the lifetime of the animals. They are also used as indicators of environmental health, for example both providing information about accumulating toxins like heavy metals through the concentrations in their shells and flesh and also in their preference for less contaminated sediment45.

**Noise**

There is limited evidence of the impacts of sound on ocean quahogs, but a study of another bivalve mollusc, a scallop species in Australia, showed serious larval abnormalities and high larval mortality as a result of seismic surveys46.

This species’ value to science and extreme vulnerability to disturbance and slow recovery rate are some of the reasons why the ocean quahog is on the OSPAR list of threatened and/or declining species and habitats in the North Sea47. OSPAR Recommendation 2020/01 increased the level of concern around the species “to strengthen the protection of the ocean quahog at all life stages in order to recover its population, to improve its status and to ensure that the population effectively conserved in Region II [North Sea] and in the part of Region III [Celtic Sea] eastwards of 5° West of the OSPAR maritime area.”

## **Ocean quahog: Summary table**

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| **Species** | **Ocean quahog** |
| **Ecological importance** | Important for productivity of sand/sediment habitats and can be present in large numbers36. Important prey species for cod and other fish48. |
| **Key life history traits** | Very long lived and slow growing and slow to reach maturity (not until ~10 years), therefore very slow to recover from damage and disturbance. Regeneration time estimated at 83 years9. |
| **Conservation status** | OSPAR List of threatened and declining species32 Feature of Conservation Importance for which Marine Conservation Zones can be designated49. Critically endangered in Baltic Sea3 |
| **Climate solution value** | An important species for studying past changes in climate and sea temperature and chemistry38. A sentinel for climate change37. |
| **Main oil and gas impacts** |  |
| **Noise** | Not studied in quahog but seismic sound caused abnormalities in larval bivalve scallops46. |
| **Pollution** | Very susceptible to chemical pollution - accumulate substances such as heavy metals over long lifespan50. |
| **Habitat loss** | If high density areas correspond with development sites for oil and gas and associated infrastructure loss to suitable habitat and impact on populations can be significant36,47. Evidence for dumping of oil and gas waste in areas of importance for ocean quahog. |
| **Impacts of plastics** | Many filter-feeding bivalves have been recorded ingesting microplastics and given the longevity of ocean quahogs it is likely that they do too. |
| **Impact of climate change** | A northern species with proven sensitivity to sea temperature increases affecting recruitment (number of offspring) and feeding behaviour51. |
| **Specific areas of concern/example of conflict** | Threats reported from Faroe-Shetland Sponge Belt MPA – oil and gas development in vicinity of ocean quahog habitat52. |

# 3. Deep-sea sponge communities – Full Case Study

Deep-sea sponge habitats have only really been studied in depth in recent decades as research technology has made them more accessible, but they are revealing themselves to be hotspots of marine biodiversity53. Sponges play an essential role in the ecology of many deep-sea ecosystems and this is particularly true of some of the deep-sea areas of most interest for oil and gas development. With unique species and assemblages they deliver a wide range of important ecological functions including an important contribution to global biogeochemical cycling54. They play an essential role in the cycling of organic matter in the deep-sea55, largely through the vast volumes of seawater they are able to filter as they extract nutrients either as Particulate Organic Matter (POM) and Dissolved Organic Matter (DOM). They are also important nursery grounds for many fishery species including rockfish, hake and blue ling56.

They are slow growing and can take decades to reach a large size57. Sponges are also incredibly long-lived, with individual sponges having been aged at hundreds and even thousands of years old56. Therefore, recovery from any disturbance is likely to take many years (possibly centuries) if adversely affected58. Deep-sea sponge aggregations are also on the OSPAR Threatened and/or Declining species/habitat list32. Nevertheless, few studies have looked at the impact of oil spill pollution on deep-water sponges in the UK or globally.

Our increasing understanding of these ecosystems directly correlates with an escalation in their exploitation and the threats to their survival and much of the initial research information available on these habitats came from work associated with offshore development56 . Deeper water habitats are at higher risk from catastrophic oil spill, with one study finding a correlation between marine development activities in deeper water and higher incidence of blowouts and spills59. Whilst oil spills from tankers have decreased in frequency, deepwater blow-outs and pipeline issues have become more common60.

From the little work that has been done on the subject, it seems that sponges may be more resilient to temperature changes and ocean acidification than cold-water corals61, although one study showed a decrease in feeding in two deep-sea demosponge taxa62.

**Habitat loss**

Sponge communities are vulnerable to impacts from oil and gas developments at all stages, from exploration to decommissioning and habitat loss is the main consequence56. At the initial construction phase, disturbance of the seabed and sedimentation generated by stirring up seabed mud and sand are the main impacts. Oil drilling in the Faroe-Shetland Channel resulted in smothering the seabed over an area of 50 to 120 metres around the drilling site and significant losses of large animals like sponges, in some cases exceeding 90%63.

Drilling itself is carried out with a range of different fluids – oil-based, water-based and synthetic. Oil-based muds have largely been phased out in UK waters, as a result of OSPAR Recommendations but their impacts have been serious and widespread64. Two key studies have looked at the impact of drilling mud and cuttings on sponge communities and demonstrated the loss of sponge and other deep-sea habitat within 200 metres of the drilling activity65,66

After drilling has ceased, it takes these fragile and complex communities a long time to recover. A study of the recovery of benthic habitats at the Laggan deep-water drilling site in the Faroes-Shetland Channel found that in areas that had been covered by drill cuttings very little recovery was observed even after 10 years66. In less impacted parts of the sites studied some recovery was observed between three and ten years later. When synthetic and oil-based drilling muds were used the impact on benthic communities, could be detected up to a kilometre away67.

Sponges in the Faroe-Shetland Channel and Rosemary Bank Seamount were found to be good species to monitor marine pollution by PAHs (for example following a major oil spill) as they accumulate them from both the dissolved and particulate phase, taking a similar role to blue mussels which are used in more coastal areas68.

Whilst OSPAR69 found declines in condition in many communities of deep-sea sponges, the Faroe-Shetland Channel Nature Conservation Marine Protected Area was found to have deep-sea sponge aggregations that were improving, in terms of morphological diversity, density and body-size distribution of *Geodia* and *Phakellia*70, making it all the more important to protect these habitats from new impacts.

## Deep-sea sponge communities: Summary table

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| **Species** | **Deep-sea sponge communities** |
| **Ecological importance** | Essential for nutrient cycling  High ecological significance as biodiversity hotspots and as nursery grounds for various fish species  Monitor species for pollution |
| **Key life history traits** | * Slow growth rates * Very high longevity * Poorly known reproductive patterns |
| **Conservation status** | OSPAR habitat: Deep–sea sponge aggregations – considered in poor condition in the Greater North Sea and considered in decline in all areas where it is found69  Habitats Directive - Annex 1: Reefs  FAO Vulnerable Marine Ecosystems71 |
| **Ecosystem services value** | Proving to be a valuable source of pharmaceuticals53 |
| **Climate solution value** | Diverse sponge communities may prove to be relatively resilient to climate change and maintain healthy and diverse populations in warmer and more acidic seas. |
| **Main oil and gas impacts** |  |
| **Habitat loss** | Sponge communities are loss directly in footprint of infrastructure and in a wide radius of impact by smothering, sedimentation and contamination56. |
| **Pollution** | Evidence of susceptibility to oil contamination, with impacts on membranes. Some species can survive relatively high levels of oil pollution but with an impact on fitness and reproduction. |
| **Climate change impacts** | Sponges are vulnerable to changes in oceanic conditions70 and wider climate change impacts are still being studied. |
| **Plastics impact** | Sponges ingest microplastics but little is know about the impact. |

# 4. Cold-water coral reefs – short case study

Cold-water coral reefs are rich, diverse, beautiful and relatively new to science, mainly because of the advanced survey technology required to research these relatively inaccessible habitats. They are known to be hotspots of biodiversity and of biomass72, are amongst the most diverse and productive deep-sea habitats73 and provide a wide range of ecosystem services74. They build substantial and extensive reef structures which can be thousands of years old, with some that have been confirmed as growing continuously for as much as 11,000 years75. These structures play an important ecological role in deep-sea ecosystems, for example providing a nursery area for many species of fish76–78. Like the ocean quahog, and their warm water counterparts, cold-water corals can provide a valuable record of climatic changes over long periods of time79. They are also important for carbon cycling in the deep-sea55. Many cold-water coral reefs are also in the vicinity of oil and gas development sites and exploration areas80 and there have been numerous studies of the impacts 81–85

**Habitat loss**

Corals are vulnerable to sedimentation which impacts on their function, so any activity that produces a lot of loose sediment can be problematic and the drilling stage of oil and gas extraction if of particular concern. Smothering by drill cuttings and drilling muds can degrade cold-water coral communities in deep waters via smothering and toxic effects81–83. Barite can be discharged in water-based mud cuttings which can impact on cold-water corals through sedimentation and whilst in the water column. Colonies have been buried by drilling cuttings leading to the death of coral polyps83 Suspended cuttings may also cause the cilia of the UK cold-water coral *Lophelia pertusa* to become clogged, hindering larvae from swimming actively, which causes larvae to sink and ultimately cause mortality80.

**Pollution**

The risk of major deep water oil spills increases as oil production moves into deeper and more challenging waters. Cold-water coral reefs are particularly vulnerable to these deep water spills, with plenty of evidence of large scale, long term impacts to these habitats as a result of the Deep Water Horizon deep water blow out in the Gulf of Mexico86,87.

**Noise**

Limited research has been done on the impacts of noise pollution on cold-water corals, but one study was able to document the changing soundscape around a cold-water coral reef as a result of less shipping activity during the Covid-19 lockdowns88. A recent review examined the evidence for impact of underwater noise on coral reef habitats and found a wide range of effects89.

**Climate change**

Tropical corals have already been demonstrated to be extremely sensitive to rising sea temperatures, with the occurrence of mass bleaching when higher temperatures are sustained90 and it has also been shown that species like *Lophelia pertusa* have critical thresholds for both temperature and ocean chemistry over which they cannot survive91.

## **Cold-water corals: Summary table**

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| **Species** | **Cold-water corals** |
| **Ecological importance** | Hotspots of productivity and biodiversity in the deep-sea74, important fish habitat and nursery areas76,77 |
| **Key life history traits** | Long-lived and slow growing – on scale of thousands of years, hence very slow recovery to damage75. |
| **Conservation status** | UK Feature of Conservation Importance for MPA designation49. OSPAR List of Threatened and/or Declining Species and Habitats32  Data Deficient’ on the IUCN Red List of Threatened Species92.  Deep-sea Vulnerable Marine Ecosystem71,93 |
| **Climate solution value** | An important role in carbon cycling in deep-sea ecosystems55 |
| **Main oil and gas impacts** |  |
| **Noise** | Not studied directly but abundant evidence for noise impact on tropical coral reefs89. |
| **Pollution** | Short and long term serious impacts from oil spill pollution demonstrated in a wide radius of impact (e.g. from Deepwater Horizon spill)86  Also vulnerable to dispersants94 |
| **Impacts of drilling** | Discharge of drill cuttings and drilling muds impact cold-water coral communities in deep waters via smothering and toxic effects. |
| **Impact of climate change** | Vulnerable to temperature increases and ocean acidification95. |
| **Impact of plastics** | Plastics have been shown to impact cold-water coral feeding, growth and behaviour96. |

# 5. Whales Case Study – short case study

UK waters are important for a surprising number of resident and migrating whale species4. Minke whales are common inshore, and humpback whales, sei whales, fin whales and other species regularly use offshore areas97. Highly endangered blue whales also use UK offshore waters and are listed on the OSPAR list of threatened and declining species32. Whales are important in marine ecosystems and their wider value is increasingly being appreciate, for example in creating blue carbon stores33. They are protected by domestic legislation and international conventions and are iconic species for conservation but they are also threatened by climate change98, for example rising sea temperatures are changing the migratory patterns of humpback whales99.

International studies of offshore oil and gas developments have demonstrated the potential for long-term detrimental effects on individual whales and on their populations100. Oil spills and chronic pollution are a particular issue for long-lived marine mammals which can accumulate toxins and pass them to their young11,13, with impacts on their health and their capacity to breed.

All whales have a high level of dependence on sound for feeding, breeding and other social behaviour and so noise from oil and gas activity is also a major issue. Seismic surveys have been reported to cause permanent damage to the hearing of a number of species of whales, and can cause sustained and severe disturbance. Seismic sound can be heard 3000 miles away from source and can mask the sounds of whale communication100.

Whale species which are deep-diving are thought to be most affected by underwater noise101–103 so long-finned pilot whales which are common in the Faroe-Shetland Sponge Belt NCMPA are particularly likely to be adversely affected by current and new oil and gas developments within and adjacent to these Marine Protected Areas. Endangered fin whales in the North East Atlantic changed their song patterns and moved away from seismic survey activity and didn’t return immediately, with potential implications for feeding and reproduction104.

There are lots of international studies highlighting the multiple and cumulative impacts of offshore oil and gas on whales. Multiple impacts of seismic and other noise on gray whales were reported from the east coast of North America. Whales showed startle behaviour at the onset of noise and avoidance of the area. In the aftermath of the Exxon Valdez spill in Alaska they were seen swimming through surface oil and showed limited avoidance of the spill105. Modelling work following the Deep Water Horizon oil spill in the Gulf of Mexico predicted major long term impacts of the spill on sperm whale populations and also highlighted the impact of disruptive seismic surveys on the species and the increased likelihood of behaviour changes, starvation, miscarriage and pup abandonment106.

Effective mitigation measures in marine developments and high levels of protection for relevant Marine Protected Areas have both been identified107 as essential for the recovery of endangered whale species, both of which are undermined by continuing to license new oil and gas developments. Nature conservation agencies are concerned about the impact of offshore energy developments on whales. For example, in the JNCC/NE response to OESEA4 consultation they raise concerns about cumulative impacts and highlight the need for a more precautionary approach108.

## Whales: Summary table

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| **Species** | **Whales** |
| **Ecological importance** | Very high – top predator/high biomass |
| **Key life history traits** | Long-lived, slow growth, later maturity and produce small numbers of young |
| **Conservation status** | Protected under UK legislation (& EU Habitats and Species Directive) |
| **Ecosystem services value** | Important role in productivity and nutrient cycling |
| **Climate solution value** | Contribute to blue carbon when carcass sinks to deep-sea bed and through nutrient input from faeces33. |
| **Main oil and gas impacts** |  |
| **Noise** | * Physical impacts such as deafness * Avoidance and other behaviour change * Decreased communication * Changes to migratory patterns * Impacts on reproduction106 |
| **Pollution** | Accumulation of persistent pollutants  Transfer of pollutants to young in milk |
| **Habitat loss** | Habitats such as cold-water coral reefs, sponge aggregations, sand-banks and offshore sediments are all at risk from oil and gas construction and operation67 and are all important for fish, squid and other species and for the ecosystems that sustain whales. |
| **Cumulative impacts** | Cumulative effects of all the impacts above are of particular concern for long-lived, wide-ranging species like whales. It is very difficult to prove impact and therefore very difficult to manage the range of factors while oil and gas activity continues. |
| **Climate change impacts** | Sea temperature rise is changing availability of plankton and other prey species and climate change is already thought to be undermining conservation efforts98. |
| **Plastic impacts** | Whales are ingesting plastics and also suffering other impacts from both marine litter and microplastics in the foodchain109. |

# 6. European otter – short case study

The European otter (*Lutra lutra*) is a protected species in UK waters under the Wildlife and Countryside Act, Priority Species under the UK Post-2010 Biodiversity Framework. European Protected Species under Annex IV of the European Habitats Directive and listed as Near Threatened on the global IUCN Red List of Threatened Species110 and vulnerable in Scotland and Wales.

Their distribution in the UK is inland and coastal. Whilst they do not occur offshore, they are known to have significant populations in Shetland and other coastal areas close to significant oil and gas developments, so they are subject to oil and gas impacts where they impact on coastal ecosystems.

Sea otters are known to be particularly vulnerable to oil pollution111. In general, marine mammals which rely on fur for insulation rather than blubber are more vulnerable to the impacts of oil spills112. A study of 13 otters which died as a result of an oil spill (caused by damage to a docking oil tanker and the spillage of 1200 tonnes of bunker fuel oil) at the Sullom Voe oil terminal in Shetland in 1978113 found that death was due to haemorrhagic gastroenteropathy caused by swallowing oil, thought to be ingested while attempting to groom and possibly from eating oiled seabirds. The otters in this case did not appear to perceive the oil pollution event as a threat and continued to swim and dive in the heavily polluted water.

A later study of European otters in Shetland114 found that numbers had increased in all locations studied, with the exception of on South Mainland which was where the Braer tanker ran aground in 1993 spilling 84,000 tonnes of crude oil113.

## European otter: Summary table

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| **Species** | **Otter** |
| **Ecological importance** | Important predator – otters also often described as keystone species111 – essential for shaping ecosystems including kelp forests. |
| **Key life history traits** | Produce small numbers of young and mothers feed young with milk, which can lead to accumulation of toxins e.g. PCBs115 |
| **Conservation status** | UK Biodiversity Action Plan (UKBAP) priority species |
| **Climate solution value** | Studies in North America have highlighted the potential for otters to contribute significantly to blue carbon, through transferring kelp to deeper seabed and also through their association with the health of eelgrass meadows.34 |
| **Main oil and gas impacts** |  |
| **Noise** | Very little information found on this. |
| **Pollution** | Otters are almost exclusively coastal, so are vulnerable to large scale oil spills which reach land.  They are very vulnerable to ingesting oil pollution.  They are also at risk from historic pollution from the oil and gas industry when digging in sediment and exposing contaminated layers (evidence of this after Exxon Valdez spill in 1989)116. |
| **Habitat loss** | Habitat loss from oil spills on the coast of from inshore/coastal oil and gas infrastructure may impact on prey. |
| **Impacts of plastics** | Known to ingest microplastics117. |
| **Sites of particular concern** | Yell Sound Coast SAC118 – very important for otters and vulnerable to major oil spills from offshore oil drilling. |

# References

1. Santos, M. & Pierce, G. The diet of harbour porpoise (Phocoena phocoena) in the Northeast Atlantic. *Oceanogr Mar Biol Annu Rev* **41**, 355–390 (2003).

2. IAMMWG, C. C. & Siemensma, M. A Conservation Literature Review for the Harbour Porpoise (Phocoena phocoena). *JNCC Report* (2015).

3. HELCOM. *Red List of Baltic Sea underwater biotopes, habitats and biotope complexes*. (2013).

4. Evans, P. & Waggitt, J. Impacts of climate change on Marine Mammals, relevant to the coastal and marine environment around the UK. (2020).

5. Santos, M. B., Clarke, M. R. & Pierce, G. J. Assessing the importance of cephalopods in the diets of marine mammals and other top predators: problems and solutions. *Fisheries Research* **52**, 121–139 (2001).

6. Sinclair, R., Sparling, C. & Harwood, J. Review Of Demographic Parameters And Sensitivity Analysis To Inform Inputs And Outputs Of Population Consequences Of Disturbance Assessments For Marine Mammals. *Scottish Marine and Freshwater Science* **11**, (2020).

7. Learmonth, J. A. *et al.* Life history of harbor porpoises (Phocoena phocoena) in Scottish (UK) waters. *Marine Mammal Science* **30**, 1427–1455 (2014).

8. Nielsen, N. H. *et al.* Oceanic movements, site fidelity and deep diving in harbour porpoises from Greenland show limited similarities to animals from the North Sea. *Marine Ecology Progress Series* **597**, 259–272 (2018).

9. JNCC. *Southern North Sea MPA – Relevant Documentation & Conservation Advice 2019*. https://hub.jncc.gov.uk/assets/206f2222-5c2b-4312-99ba-d59dfd1dec1d#SouthernNorthSea-conservation-advice.pdf (2019).

10. North Sea Transition Authority (NSTA). NSTA. 33rd Petroleum Licensing Round, Southern North Sea: SNS Cluster Rationale [Online]. https://www.nstauthority.co.uk/media/8425/sns-cluster-rationale-accessible-7-october.pdf (2022).

11. Helm, R. C. *et al.* Overview of Effects of Oil Spills on Marine Mammals. in *Handbook of Oil Spill Science and Technology* 455–475 (2014). doi:10.1002/9781118989982.ch18.

12. Law, R. J. & Whinnett, J. A. Polycyclic aromatic hydrocarbons in muscle tissue of harbour porpoises (Phocoena phocoena) from UK waters. *Marine Pollution Bulletin* **24**, 550–553 (1992).

13. Lourenço, R. A., Taniguchi, S., Silva, J. da, Gallotta, F. D. C. & Bícego, M. C. Polycyclic aromatic hydrocarbons in marine mammals: A review and synthesis. *Marine Pollution Bulletin* **171**, 112699 (2021).

14. Braulik, G., Minton, G., Amano, M. & Bjørge, A. Phocoena phocoena. *The IUCN Red List of Threatened Species* **2020**, (2020).

15. Williams, R. *et al.* Levels of polychlorinated biphenyls are still associated with toxic effects in harbor porpoises (Phocoena phocoena) despite having fallen below proposed toxicity thresholds. *Environmental Science & Technology* **54**, 2277–2286 (2020).

16. Camphuysen, C. J. & Siemensma, M. L. *Conservation plan for the Harbour Porpoise Phocoena phocoena in The Netherlands: towards a favourable conservation status*. (NIOZ Royal Netherlands Institute for Sea Research, 2011).

17. Thomsen, F. *et al.* Cetacean stock assessments in relation to exploration and production industry activity and other human pressures: review and data needs. *Aquatic Mammals* **37**, 1–93 (2011).

18. Southall, B. *et al.* Marine mammal noise exposure criteria. *Aquat. Mamm.* **33**, (2007).

19. Todd, V. L., Williamson, L. D., Couto, A. S., Todd, I. B. & Clapham, P. J. Effect of a new offshore gas platform on harbor porpoises in the Dogger Bank. *Marine Mammal Science* **38**, 1609–1622 (2022).

20. Hassel, A. *et al.* *Reaction of sand eel to seismic shooting: A field experiment and fishery statistics study*. https://www.iqoe.org/library/15972 (2003).

21. Lucke, K., Siebert, U., Lepper, P. A. & Blanchet, M.-A. Temporary shift in masked hearing thresholds in a harbor porpoise (Phocoena phocoena) after exposure to seismic airgun stimuli. *The Journal of the Acoustical Society of America* **125**, 4060–4070 (2009).

22. Ward, P. *2D seismic survey in the Moray Firth: Review of noise impact studies and re-assessment of acoustic impacts*. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment\_data/file/851549/2D\_Seismic\_Survey\_in\_the\_Moray\_Firth\_-\_Review\_of\_noise\_impact\_studies\_and\_Re-assessment\_of\_Acoustic\_Impacts.pdf (2010).

23. Thompson, P. M. *et al.* Short-term disturbance by a commercial two-dimensional seismic survey does not lead to long-term displacement of harbour porpoises. (2013).

24. Pirotta, E., Brookes, K. L., Graham, I. M. & Thompson, P. M. Variation in harbour porpoise activity in response to seismic survey noise. *Biology Letters* **10**, 20131090 (2014).

25. Sarnocińska, J. *et al.* Harbor Porpoise (Phocoena phocoena) Reaction to a 3D Seismic Airgun Survey in the North Sea. *Frontiers in Marine Science* **6**, (2020).

26. Merchant, N. D. & Robinson, S. Abatement of underwater noise pollution from pile-driving and explosions in UK waters. in vol. 12 (2019).

27. Dähne, M. *et al.* Effects of pile-driving on harbour porpoises (Phocoena phocoena) at the first offshore wind farm in Germany. *Environmental Research Letters* **8**, 025002 (2013).

28. Birkun Jr, A. Interactions between cetaceans and fisheries in the Black Sea. in *Cetaceans of the Mediterranean and Black Seas: state of knowledge and conservation strategies* vol. 98 107 (Report to the ACCOBAMS Secretariat Monaco, 2002).

29. MacLeod, C. D., Santos, M. B., Reid, R. J., Scott, B. E. & Pierce, G. J. Linking sandeel consumption and the likelihood of starvation in harbour porpoises in the Scottish North Sea: could climate change mean more starving porpoises? *Biology letters* **3**, 185–188 (2007).

30. Thompson, P. *et al.* Climate change causing starvation in harbour porpoises? *Biology Letters* **3**, 533–535 (2007).

31. Clausen, K. T. *et al.* Echolocation activity of harbour porpoises, Phocoena phocoena, shows seasonal artificial reef attraction despite elevated noise levels close to oil and gas platforms. *Ecological Solutions and Evidence* **2**, e12055 (2021).

32. OSPAR Commission. List of Threatened and/or Declining Species & Habitats. *OSPAR Commission* https://www.ospar.org/work-areas/bdc/species-habitats/list-of-threatened-declining-species-habitats (2008).

33. Pearson, H. C. *et al.* Whales in the carbon cycle: can recovery remove carbon dioxide? *Trends in Ecology & Evolution* (2022) doi:https://doi.org/10.1016/j.tree.2022.10.012.

34. Atwood, T. B. *et al.* Predators help protect carbon stocks in blue carbon ecosystems. *Nature Climate Change* **5**, 1038–1045 (2015).

35. Heuvel-Greve, M. J. van den *et al.* Polluted porpoises: Generational transfer of organic contaminants in harbour porpoises from the southern North Sea. *Science of The Total Environment* **796**, 148936 (2021).

36. Tyler-Walters, H. & Sabatini, M. Arctica islandica Icelandic cyprine. In Tyler-Walters H. and Hiscock K. (eds) Marine Life Information Network: Biology and Sensitivity Key Information Reviews. Plymouth: Marine Biological Association of the United Kingdom. in (2017).

37. Butler, P. G., Wanamaker, A. D., Scourse, J. D., Richardson, C. A. & Reynolds, D. J. Variability of marine climate on the North Icelandic Shelf in a 1357-year proxy archive based on growth increments in the bivalve Arctica islandica. *Palaeogeography, Palaeoclimatology, Palaeoecology* **373**, 141–151 (2013).

38. Schöne, B. R. Arctica islandica (Bivalvia): A unique paleoenvironmental archive of the northern North Atlantic Ocean. *Global and Planetary Change* **111**, 199–225 (2013).

39. Arellano-Nava, B. *et al.* Destabilisation of the Subpolar North Atlantic prior to the Little Ice Age. *Nature Communications* **13**, 5008 (2022).

40. Estrella-Martínez, J. *et al.* Reconstruction of Atlantic herring ( Clupea harengus ) recruitment in the North Sea for the past 455 years based on the δ 13 C from annual shell increments of the ocean quahog ( Arctica islandica ). *Fish and Fisheries* **20**, (2019).

41. Cargnelli, L., Griesbach, S., Packer, D. & Weissberger, E. Ocean quahog, Arctica islandica, life history and habitat characteristics NOAA. in *Technical Memorandum NMFS-NE-148* 1–12 (1999).

42. Witbaard, R. & Bergman, M. J. N. The distribution and population structure of the bivalve Arctica islandica L. in the North Sea: what possible factors are involved? *Journal of Sea Research* **50**, 11–25 (2003).

43. Natural England & JNCC. *Marine Conservation Zone Project Ecological Network Guidance*. https://data.jncc.gov.uk/data/94f961af-0bfc-4787-92d7-0c3bcf0fd083/MCZ-Ecological-Network-Guidance-2010.pdf (2010).

44. Hennen, D. R. How should we harvest an animal that can live for centuries? *North American Journal of Fisheries Management* **35**, 512–527 (2015).

45. Liehr, G. A., Zettler, M. L., Leipe, T. & Witt, G. The ocean quahog Arctica islandica L.: a bioindicator for contaminated sediments. *Marine Biology* **147**, 671–679 (2005).

46. Soto, N. A. *et al.* Anthropogenic noise causes body malformations and delays development in marine larvae. *Sci Rep* **3**, 1–5 (2013).

47. OSPAR Commission. *Background Document for Ocean quahog Arctica islandica*. https://qsr2010.ospar.org/media/assessments/Species/P00407\_Ocean\_quahog.pdf (2010).

48. Brey, T., Arntz, W. E., Pauly, D. & Rumohr, H. Arctica (Cyprina) islandica in Kiel Bay (Western Baltic): growth, production and ecological significance. *Journal of Experimental Marine Biology and Ecology* **136**, 217–235 (1990).

49. JNCC and Natural England. *Review of the MCZ Features of Conservation Importance*. https://data.jncc.gov.uk/data/94f961af-0bfc-4787-92d7-0c3bcf0fd083/MCZ-review-foci-201605-v7.0.pdf (2016).

50. Steimle, F.W., Boehm, P.D., Zdanowicz, V.S., & Bruno, R.A. Organic and trace metal levels in ocean quahog, Arctica islandica Linne, from the Northwestern Atlantic. *FISHERY BULLETIN* **84**, (1986).

51. Hiebenthal C, Philipp EER, Eisenhauer A, & Wahl M. Interactive effects of temperature and salinity on shell formation and general condition in Baltic Sea Mytilus edulis and Arctica islandica. *Aquat Biol* **14**, 289–298 (2012).

52. JNCC. *Faroe-Shetland Sponge Belt Nature Conservation Marine Protected Area: Data Confidence Assessment.* https://data.jncc.gov.uk/data/411ea794-b135-4877-9fc8-e3e6c054eef9/FSSB-2-DataConfidenceAssessment-v5.0.pdf (2014).

53. Hogg, M. *et al.* Deep-sea sponge grounds: reservoirs of biodiversity. *UNEP-WCMC biodiversity series* **32**, 1–86 (2010).

54. Ramirez-Llodra, E. *et al.* Man and the Last Great Wilderness: Human Impact on the Deep Sea. *PLOS ONE* **6**, e22588 (2011).

55. Cathalot, C. *et al.* Cold-water coral reefs and adjacent sponge grounds: hotspots of benthic respiration and organic carbon cycling in the deep sea. *Frontiers in Marine Science* **2**, (2015).

56. Vad, J. *et al.* Chapter Two - Potential Impacts of Offshore Oil and Gas Activities on Deep-Sea Sponges and the Habitats They Form. in *Advances in Marine Biology* (ed. Sheppard, C.) vol. 79 33–60 (Academic Press, 2018).

57. Readman, J.A.J. *Readman, J.A.J., 2018. Deep sponge communities. In Tyler-Walters H. and Hiscock K. (eds) Marine Life Information Network: Biology and Sensitivity Key Information Reviews, [on-line]. Plymouth: Marine Biological Association of the United Kingdom. DOI https://dx.doi.org/10.17031/marlinhab.1081.1*. https://dx.doi.org/10.17031/marlinhab.1081.1 (2018).

58. Gubbay, S. *The Offshore Directory. Review of a selection of habitats, communities and species of the north-east Atlantic.* http://www.charlie-gibbs.org/sites/all/themes/motion/pdf/Offshore\_directory.pdf (2002).

59. Muehlenbachs, L., Cohen, M. A. & Gerarden, T. The impact of water depth on safety and environmental performance in offshore oil and gas production. *Energy Policy* **55**, 699–705 (2013).

60. Jernelöv, A. The threats from oil spills: now, then, and in the future. *Ambio* **39**, 353–366 (2010).

61. Schulz, K. G. *et al.* Temporal biomass dynamics of an Arctic plankton bloom in response to increasing levels of atmospheric carbon dioxide. *Biogeosciences* **10**, 161–180 (2013).

62. Robertson, L. M., Hamel, J.-F. & Mercier, A. Feeding in deep-sea demosponges: Influence of abiotic and biotic factors. *Deep Sea Research Part I: Oceanographic Research Papers* **127**, 49–56 (2017).

63. Daniel O. B. Jones, Ian R. Hudson, & Brian J. Bett. Effects of physical disturbance on the cold-water megafaunal communities of the Faroe–Shetland Channel. *Mar Ecol Prog Ser* **319**, 43–54 (2006).

64. Henry, L.-A., Harries, D., Kingston, P. & Roberts, J. M. Historic scale and persistence of drill cuttings impacts on North Sea benthos. *Marine Environmental Research* **129**, 219–228 (2017).

65. Gates, A. R. & Jones, D. O. B. Recovery of Benthic Megafauna from Anthropogenic Disturbance at a Hydrocarbon Drilling Well (380 m Depth in the Norwegian Sea). *PLOS ONE* **7**, e44114 (2012).

66. Jones DOB, Gates AR, & Lausen B. Recovery of deep-water megafaunal assemblages from hydrocarbon drilling disturbance in the Faroe−Shetland Channel. *Mar Ecol Prog Ser* **461**, 71–82 (2012).

67. Ellis, J., Fraser, G. & J, R. Discharged drilling waste from oil and gas platforms and its effects on benthic communities. *Marine Ecology Progress Series* **456**, 285–302 (2012).

68. Webster, L. *et al.* Monitoring of Polycyclic Aromatic Hydrocarbons (PAHs) in Scottish Deepwater environments. *Marine Pollution Bulletin* **128**, 456–459 (2018).

69. OSPAR Commission. Deep-Sea Sponge Aggregations. *OSPAR Commission* https://www.ospar.org/work-areas/bdc/species-habitats/list-of-threatened-declining-species-habitats/habitats/deep-sea-sponge-aggregations (2022).

70. Kazanidis, G. *et al.* Distribution of Deep-Sea Sponge Aggregations in an Area of Multisectoral Activities and Changing Oceanic Conditions. *Frontiers in Marine Science* **6**, (2019).

71. ICES. *A suggestive list of deep-water VMEs and their characteristic taxa*. https://www.ices.dk/data/Documents/VME/VMEs%20and%20their%20taxa.pdf (2020).

72. De Clippele, L. *et al.* Mapping cold-water coral biomass: an approach to derive ecosystem functions. *Coral Reefs* **40**, 215–231 (2021).

73. Maier, S. R. *et al.* Recycling pathways in cold-water coral reefs: Use of dissolved organic matter and bacteria by key suspension feeding taxa. *Scientific Reports* **10**, 9942 (2020).

74. Foley, N., van Rensburg, T. & Armstrong, C. The ecological and economic value of cold-water coral ecosystems. *Ocean & Coastal Management - OCEAN COAST MANAGE* **53**, (2010).

75. Roberts, J. M., Wheeler, A. J. & Freiwald, A. Reefs of the Deep: The Biology and Geology of Cold-Water Coral Ecosystems. *Science* **312**, 543–547 (2006).

76. Baillon, S., Hamel, J.-F., Wareham, V. E. & Mercier, A. Deep cold‐water corals as nurseries for fish larvae. *Frontiers in Ecology and the Environment* **10**, 351–356 (2012).

77. Henry, L.-A. *et al.* Cold-water coral reef habitats benefit recreationally valuable sharks. *Biological conservation* **161**, 67–70 (2013).

78. Henry, L. *et al.* Seamount egg‐laying grounds of the deep‐water skate Bathyraja richardsoni. *Journal of Fish Biology* **89**, 1473–1481 (2016).

79. Douarin, M. *et al.* Changes in fossil assemblage in sediment cores from Mingulay Reef Complex (NE Atlantic): Implications for coral reef build-up. *Deep Sea Research Part II: Topical Studies in Oceanography* **99**, 286–296 (2014).

80. Järnegren, J., Brooke, S. & Jensen, H. Effects and recovery of larvae of the cold-water coral Lophelia pertusa (Desmophyllum pertusum) exposed to suspended bentonite, barite and drill cuttings. *Marine Environmental Research* **158**, 104996 (2020).

81. Lepland, A. & Mortensen, P. B. Barite and barium in sediments and coral skeletons around the hydrocarbon exploration drilling site in the Træna Deep, Norwegian Sea. *Environmental Geology* **56**, 119–129 (2008).

82. Purser, A. & Thomsen, L. Monitoring strategies for drill cutting discharge in the vicinity of cold-water coral ecosystems. *Marine Pollution Bulletin* **64**, 2309–2316 (2012).

83. Larsson, A. I., Oevelen, D. van, Purser, A. & Thomsen, L. Tolerance to long-term exposure of suspended benthic sediments and drill cuttings in the cold-water coral Lophelia pertusa. *Marine Pollution Bulletin* **70**, 176–188 (2013).

84. Godø, O. R. *et al.* Real time observation system for monitoring environmental impact on marine ecosystems from oil drilling operations. *Marine Pollution Bulletin* **84**, 236–250 (2014).

85. Buhl-Mortensen, L. *et al.* Biological structures as a source of habitat heterogeneity and biodiversity on the deep ocean margins. *Marine Ecology* **31**, 21–50 (2010).

86. Fisher, C. R. *et al.* Footprint of Deepwater Horizon blowout impact to deep-water coral communities. *Proceedings of the National Academy of Sciences* **111**, 11744–11749 (2014).

87. Fisher, C. R. *et al.* Coral Communities as Indicators of Ecosystem-Level Impacts of the Deepwater Horizon Spill. *BioScience* **64**, 796–807 (2014).

88. De Clippele, L. H. & Risch, D. Measuring Sound at a Cold-Water Coral Reef to Assess the Impact of COVID-19 on Noise Pollution. *Frontiers in Marine Science* **8**, (2021).

89. Ferrier-Pagès, C. *et al.* Noise pollution on coral reefs? — A yet underestimated threat to coral reef communities. *Marine Pollution Bulletin* **165**, 112129 (2021).

90. Skirving, W. J. *et al.* The relentless march of mass coral bleaching: a global perspective of changing heat stress. *Coral Reefs* **38**, 547–557 (2019).

91. Bindoff, N. L. *et al.* Changing ocean, marine ecosystems, and dependent communities. *IPCC special report on the ocean and cryosphere in a changing climate* 477–587 (2019).

92. IUCN. The IUCN Red List of Threatened Species. *IUCN Red List of Threatened Species* https://www.iucnredlist.org/en (2011).

93. ICES. ICES VME Portal [Online]. https://vme.ices.dk/map.aspx (2020).

94. DeLeo, D. M., Ruiz-Ramos, D. V., Baums, I. B. & Cordes, E. E. Response of deep-water corals to oil and chemical dispersant exposure. *Deep Sea Research Part II: Topical Studies in Oceanography* **129**, 137–147 (2016).

95. Jackson, E. L., Davies, A. J., Howell, K. L., Kershaw, P. J. & Hall-Spencer, J. M. Future-proofing marine protected area networks for cold water coral reefs. *ICES Journal of Marine Science* **71**, 2621–2629 (2014).

96. Chapron, L. *et al.* Macro- and microplastics affect cold-water corals growth, feeding and behaviour. *Scientific Reports* **8**, 15299 (2018).

97. Hammond, P. *et al.* *Estimates of cetacean abundance in European Atlantic waters in summer 2016 from the SCANS-III aerial and shipboard surveys*. (2017).

98. Tulloch, V. J. D., Plagányi, É. E., Brown, C., Richardson, A. J. & Matear, R. Future recovery of baleen whales is imperiled by climate change. *Global Change Biology* **25**, 1263–1281 (2019).

99. Braithwaite, J., Meeuwig, J. & Hipsey, M. Optimal migration energetics of humpback whales and the implications of disturbance. *Conservation Physiology* (2015).

100. Parsons, E. C. M., Clark, J., Warham, J. & Simmonds, M. P. The Conservation of British Cetaceans: A Review of the Threats and Protection Afforded to Whales, Dolphins, and Porpoises in UK Waters, Part 1. *Journal of International Wildlife Law & Policy* **13**, 1–62 (2010).

101. Cox, T. M. *et al.* *Understanding the impacts of anthropogenic sound on beaked whales*. (2006).

102. Stone, C. J. & Tasker, M. L. The effects of seismic airguns on cetaceans in UK waters. *Journal of Cetacean Research and Management* **8**, 255 (2006).

103. McGeady, R., McMahon, B. J. & Berrow, S. The effects of seismic surveying and environmental variables on deep diving odontocete stranding rates along Ireland’s coast. in vol. 27 040006 (Acoustical Society of America, 2016).

104. Castellote, M., Clark, C. W. & Lammers, M. O. Acoustic and behavioural changes by fin whales (Balaenoptera physalus) in response to shipping and airgun noise. *Biological Conservation* **147**, 115–122 (2012).

105. Moore, S. & Clarke, J. T. Potential impact of offshore human activities on gray whales(Eschrichtius robustus. *Journal of cetacean research and management* **4**, 19–25 (2002).

106. Farmer, N. A. *et al.* Population consequences of disturbance by offshore oil and gas activity for endangered sperm whales (Physeter macrocephalus). *Biological Conservation* **227**, 189–204 (2018).

107. Koubrak, O., VanderZwaag, D. L. & Worm, B. Endangered Blue Whale Survival in the North Atlantic: Lagging Scientific and Governance Responses, Charting Future Courses. *The International Journal of Marine and Coastal Law* **37**, 89–136 (2022).

108. BEIS. *UK Offshore Energy Strategic Environmental Assessment - Consultation Feedback*. (2022).

109. Roman, L., Schuyler, Q., Wilcox, C. & Hardesty, B. D. Plastic pollution is killing marine megafauna, but how do we prioritize policies to reduce mortality? *Conservation Letters* **14**, e12781 (2021).

110. Roos, A., Loy, A., de Silva, P., Hajkova, P. & Zemanová, B. Lutra lutra. The IUCN Red List of Threatened Species 2015: e. T12419A21935287. (2015).

111. Estes, J. A. Chapter 2 - Natural History, Ecology, and the Conservation and Management of Sea Otters. in *Sea Otter Conservation* (eds. Larson, S. E., Bodkin, J. L. & VanBlaricom, G. R.) 19–41 (Academic Press, 2015). doi:https://doi.org/10.1016/B978-0-12-801402-8.00002-0.

112. Kooyman, G. L., Davis, R. W. & Castellini, M. A. CHAPTER 14 - THERMAL CONDUCTANCE OF IMMERSED PRINNIPED AND SEA OTTER PELTS BEFORE AND AFTER OILING WITH PRUDHOE BAY CRUDE. in *Fate and Effects of Petroleum Hydrocarbons in Marine Ecosystems and Organisms* (ed. Wolfe, D. A.) 151–157 (Pergamon, 1977). doi:https://doi.org/10.1016/B978-0-08-021613-3.50019-X.

113. Baker, J. R., Jones, A. M., Jones, T. P. & Watson, H. C. Otter Lutra lutra L. mortality and marine oil pollution. *Biological Conservation* **20**, 311–321 (1981).

114. Conroy, J. & Kruuk, H. Changes in Otter Numbers in Shetland Between 1988 and 1993. *Oryx* vol. 29 197–204 (1995).

115. Esposito, M. *et al.* First study on PCBs, organochlorine pesticides, and trace elements in the Eurasian otter (Lutra lutra) from southern Italy. *Science of The Total Environment* **749**, 141452 (2020).

116. Bodkin JL *et al.* Long-term effects of the Exxon Valdez oil spill: sea otter foraging in the intertidal as a pathway of exposure to lingering oil. *Mar Ecol Prog Ser* **447**, 273–287 (2012).

117. O’Connor, J. D. *et al.* Microplastics in Eurasian otter (Lutra lutra) spraints and their potential as a biomonitoring tool in freshwater systems. *Ecosphere* **13**, e3955 (2022).

118. JNCC. Yell Sound Coast. https://sac.jncc.gov.uk/site/UK0012687 (Undated).