MARINE ~~PROTECTED~~ UNPROTECTED AREAS

A case for a just transition to ban bottom trawl and dredge fishing in offshore Marine Protected Areas

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Headline figures

The study examined fishing effort in all Marine Protected Areas (Special Areas of Conservation, Marine Conservation Zones and nature conservation Marine Protected Areas, hereafter collectively referred to as MPAs) in UK offshore waters (beyond 12 nautical miles) designated to protect the seabed, and the implications for biodiversity recovery and carbon storage.

All but one offshore MPA designated to protect the seabed experienced demersal towed fishing between 2015-2018.

Half of all offshore MPAs designated to protect the seabed before 2018 have experienced at least 1,000 hours of demersal fishing between 2015 and 2018.

12% of all offshore benthic MPAs designated before 2018 have experienced at least 5,000 hours of demersal fishing between 2015 and 2018.

Between 2015 and 2018, the sandbanks and reefs offered "protection" by the UK's offshore MPAs have experienced at least 89,894 hours of fishing effort by vessels using bottom-contacting mobile gear.

The UK fleet was responsible for 43% of demersal fishing recorded inside offshore MPAs between 2015 and 2018 and 63% of the fishing conducted outside these MPAs.

The non-UK EU fleet were responsible for 57% of the demersal fishing recorded inside offshore MPAs designated to protect the seabed between 2015 and 2018[1].

The highest fishing rates since site designation were found in *Central Fladen ncMPA* (northern North Sea in offshore Scottish waters)*, Margate and Long Sands* Special Area of Conservation (SAC) (off the Kent coast) and *Haisborough, Hammond and Winterton* SAC (off the Norfolk coast) with these sites experiencing fishing across 95-100% of their surface area. UK, Belgian, and Dutch fleets were the dominant vessels operating in these MPAs respectively.

Areas designated as Marine Conservation Zones in 2019 experienced the highest fishing rates of all MPAs assessed between 2015 and 2018. Despite now being designated Marine Conservation Zones, there are no fishing restrictions to prevent this level of fishing continuing.

Dogger bank

The UK's Dogger Bank SAC experienced over 2,500 hours (at least 2,623.41 hours) of demersal fishing between 2015 and 2018, the UK and Dutch fleets were responsible for the majority of this activity.

Dogger Bank SAC has the capacity to store around 5 Mt carbon. The release of carbon from the site by continued trawling could cost the UK economy nearly £200 million to mitigate over the next 25-years.

[1] only UK and EU vessels were included in analysis

Executive Summary

Over 120 years of industrial fishing has depleted and distorted the UK's marine environment, which, combined with the profound effects of climate change, means effective management is needed now more than ever. The protection of the marine environment through the designation of well-managed MPAs would serve not only to restore marine ecosystems and enhance sustainable fishing, but, since 205 megatonnes of carbon are estimated to be stored in UK offshore shelf sediments (Luisetti et al., 2019), it will also equip us with a valuable tool for combating climate change.

On paper 36% of all UK waters have been designated in some form of MPA[2] due to the presence of a vulnerable species and/or habitat. In English seas, MPA coverage equates to 40%[3] of all waters, however, only 2% of the English seabed is actually offered legal protection from bottom trawling & dredging; these small areas fall overwhelmingly within inshore waters in habitats off-limits to bottom towed gears[4].

Using fishing effort data provided by Global Fishing Watch, this report finds MPAs designated for the seabed[5] to provide very little, if any, protection against mobile demersal fishing gears offshore. Between 2015 and 2018, vessels using demersal trawl, dredge and/or seine gear fished for a total of at least 89,894 hours within the boundaries of offshore MPAs designated for benthic features equating to approximately 10 years' worth of continuous fishing activity.

Our analysis finds that, all but one offshore MPA designated to protect the seabed experienced demersal fishing between 2015-2018; a finding that is of particular concern as the first pass of the trawl is often the most destructive (Kaiser, 2006). The extent of trawling activity varies between sites. Half of all MPAs designated for benthic features experienced at least 1,000 hours of demersal fishing within their boundaries between 2015 and 2018; a figure that rises to at least 5,000 hours in 12% of offshore sites. The highest fishing rates were found in *Central Fladen ncMPA* (a nature conservation MPA in the northern North Sea in the Scottish offshore area), *Margate and Long Sands* Special Area of Conservation (SAC) (off the Kent coast) and *Haisborough, Hammond and Winterton* SAC (off the Norfolk coast) where the UK, Belgian, and Dutch fleets were responsible for the greatest proportion of fishing in the respective sites. However, the highest fishing rates of all were, in fact, found in the areas designated as MCZs in English offshore waters in 2019. Whilst these sites were designated after the period captured by our fishing data, at present there are no fishing restrictions in place to prevent this level of fishing continuing. It is therefore paramount that greater management measures are implemented.

In this report we analyse data from Luisetti et al (2019) in terms of sea shelf sediment carbon values. We found that there is considerable resource that can be protected and enhanced by banning bottom towed fishing in offshore MPAs. We calculate that the blue carbon stored within UK offshore MPAs (<200m depth) equates to the amount of carbon released by 4 million return flights to Sydney.

Dogger Bank SAC, an MPA comprised entirely of shelf sediment, is found to have the capacity to store over 5 Mt carbon. Carbon emissions released as a result of continued trawling within this site could

[2] Value includes Special Areas of Conservation (SACs) and Special Protection Areas (SPAs) under the Habitats Regulations; Marine Conservations Zones (England, Wales and Northern Ireland) and nature conservation Marine Protected Areas (Scotland).

[3] https://map.mpa-reality-check.org/information/

[4] See MPA Reality Check for spatial data on these sites: https://map.mpa-reality-check.org/

[5] In this study "MPAs" henceforth collectively refer to Special Areas of Conservation (SACs) under the Habitats Regulations, Marine Conservations Zones (England, Wales and Northern Ireland) and nature conservation Marine Protected Areas (Scotland) that are designated for benthic features unless otherwise stated.

cost the UK economy over £7 million a year to mitigate. This report finds that the site is predominantly fished by UK and Dutch demersal fleets with at least 2,500 hours of fishing using demersal trawls, seines and dredges recorded inside the MPA between 2015 and 2018.

RECOMMENDATIONS

The UK urgently needs effectively managed Marine Protected Areas to help recover our marine species and habitats, support sustainable fishing and combat climate change.

Now is the time to begin a just transition towards a complete ban on bottom trawling, seining and dredging in offshore Marine Protected Areas designated to protect seabed species and habitats. This transition can only happen by working with local communities and all who benefit from marine resources. The Fisheries Act 2020 provides the opportunity for the UK Government (for England) and the Scottish, Welsh and Northern Irish Governments to manage fisheries in offshore protected areas in their respective jurisdictions.

The commitment to a 'whole-site approach' to managing MPAs within the Department for Environment, Food and Rural Affairs' 25-year plan for English waters, when applied to all sites where mosaics of habitats are mutually beneficial for biodiversity, life-history stages of constituent species and essential fish habitat, provides the potential for the Marine Management Organisation to close offshore seabed designation Marine Protected Areas to bottom trawling, allowing for the recovery, restoration and reparation of entire ecosystems.

The data in this report shows that the government must now ensure that it takes into account the carbon released by human activities – in particular in this case by bottom towed fishing gears – as well as the carbon stored in the marine environment in its carbon accounting. This is imperative moving forwards, particularly considering 93% of the carbon stored in the continental seas of the UK is held in shelf sediments. Investment is needed to establish a good understanding of sediment to blue carbon pathways. Protecting the seabed from bottom towed fishing gear for carbon as well as biodiversity will allow biomass to accumulate thus enriching the UK's blue carbon stores.

In Wales, we are awaiting the designation of offshore Marine Conservation Zones for important seabed species and habitats. Following designation, the Welsh Government should introduce strict management measures within these sites that will prevent damage to the seabed and associated species.

In Scotland, proposed fisheries management measures for offshore MPAs have stalled in the Common Fisheries Policy process. These should be updated by the Scottish Government in response to the intertwined climate and nature crises to deliver a whole-site approach to seabed protection. An independent commission should also be established to recommend transformation of Scotland's Marine Protected Area network and help ensure at least a third of Scotland's seas are highly or fully protected by 2030.

What is key, is that additional regulatory measures be introduced urgently across all UK countries. Introducing new conditions on the general fishing license would be a quick and efficient way of doing this. The MMO's preferred approach of introducing byelaws is currently much more time-consuming. If it is used, it must be speeded up. In either case, remote electronic (real-time) monitoring with cameras on vessels will also be key to help monitor catches and support compliance with management measures.

To date, agreeing fisheries management measures for Marine Protected Areas through a complex Common Fisheries Policy process has been complicated by changing constitutional dynamics between the EU and UK.

Now, with the powers provided by The Fisheries Act 2020, the UK Governments can act more independently to recover our seas and combat climate change.

Introduction

Fishing continues to have the most significant direct impact on the marine environment (IPBES, 2019). Recent concerns about climate change and its multifarious effects on our planet are now adding to the impact from over 120 years of industrial fishing. A recent international report has shown that the ocean-based measures, including implementation of renewable energy resources at sea; sustainable management of fisheries; and fully-protected marine reserves could result in the oceans helping to provide 20% or more of the necessary carbon sequestration we need to keep global warming within 1.5° Celsius by 2100 (Hoegh-Guldberg et al., 2019). As yet we currently have no fully-protected marine reserves in our offshore seas, even though we have many 'Marine Protected Areas', and virtually no areas free from seabed trawling.

Biomass of large fish and predator species over the past 140 years has seen a 90% decline (Thurstan et al. et al., 2010; Myers & Worm 2003), with a collateral reduction in benthic productivity and ecosystem function (loss of bivalves and filter feeders on the seabed). This has had considerable negative consequences for the carbon cycle (Roberts et al., 2017). Marine Protected Areas (MPAs), if implemented effectively, could help combat climate change. The United Kingdom has only 4 very small fully-protected marine reserves[6], measuring less than 25km^2 [7] in over 800,000km^2 of sea area. Overall, we have 358 'Marine Protected Areas' in UK seas[8], however, very few of these sites are protected from fishing. This number includes 70[9] offshore sites (outside 12nm) designated to protect the seabed, none of which have management plans that restrict fishing. These offshore sites cover a total of 245,529 km^2.

A recent publication in *Science* found that fishing occurs in 60% of Europe's MPAs (Dureuil et al., 2018). Fisheries management measures must be changed to meet climate (SUDG goal 13), biodiversity (SUDG goal 14) and food security (SUDG goal 2) (Cabral et al., 2019) obligations under the UN 2014 Sustainable Development goals.

Why are our Marine Protected Areas (MPAs) failing to deliver recovery?

English seas have seen only 2% of waters legally protected from bottom trawling[10]. The majority of these management measures are currently in place to protect inshore 'reef' areas where trawls don't operate because the fishing gear would be damaged. Of the sand, mud, gravel and sediment habitats in English MPAs where fishing can take place, we calculate that only 0.98% of English seas are closed to bottom trawling, and all such measures have only partially been established in coastal waters (less than 12 nautical miles from the coast). Scottish Government scientists similarly calculated that only 2.5% of inshore seabed, between mean high water at spring tide and 12 nautical miles around mainland Scotland and associated islands, was protected from use of mobile bottom fishing gear. The Marine Scotland Science study calculated that the current inshore seabed protection measures

[6] Lamslash Bay, Arran, West Scotland (2.67km^2); Flamborough Head, Yorkshire (0.7km^2); Lundy, Devon (3.3km^2); Medway, Kent (12.1km^2).

[7] A recent report has called on UK Government to implement 'Highly Protected Marine Protected Areas (HPMAs)'

[8] This figure includes the West of Scotland MPA. The analysis for this report was conducted prior to this site being designated so it has not been included.

[9] Value includes the West of Scotland MPA. Analysis was conducted prior to this site being designated so it has not been included.

[10] *MPA Reality Check: About this website:* https://map.mpa-reality-check.org/information/

amounted to only 0.6% of the total 'swept area' within the study area (within 12nm) by fishers – that is where bottom towed fishing gears can physically operate (Langton et al, 2020).

Despite 358 areas (36% of UK seas)[11] designated in some form of MPA, the majority remain 'paper parks' because of continued bottom trawl fishing. This is because 1. UK coasts and seas are used extensively by many stakeholders; 2. the political power of large-scale fishing industry representatives can be an obstacle to progress on marine biodiversity conservation (Lieberknecht and Jones, 2016; Jones, 2014); 3. there is weak and/or inconsistent political will to implement wide-scale bans on damaging fishing in MPAs (for example, inshore MPAs in the Kent and Essex district and the Wash have only seen partial protection of the seabed from damaging fishing); 4. In EU waters, the Common Fisheries Policy (CFP) mechanism for bringing in protection to MPAs outside 12nm from the coast requires agreement from every member state with an expressed fishing interest in the site.

Poor ambition

A further problem lies in the ecological baselines (and hence benchmarks) that are set for the conservation of our seas, and MPAs. This has been exacerbated by the 'shifting baselines' syndrome of how society views the current condition of the natural world (Figure 1). Governments and their regulatory bodies are managing today's environment as if that is the normative state (e.g. Plummeridge and Roberts, 2017)[12]. This ignores historical ecological baselines whereby the marine ecosystem not only comprised of a greater diversity of species, but at such greater abundance and biomass that the function of the marine ecosystem was substantially different. By way of example, studies comparing the historic use of trawls in the North Sea have reported potential reductions in fish biomass of commercial species in excess of 90% (when the effort to catch fish is considered as a proxy for the abundance and biomass of species) (Thurstan et al. et al., 2010). At present, there are no large-scale 'control' areas in UK seas where there has never been bottom trawling by which accurate comparisons of the impact of over 120 years of seabed abrasion can be made. As such, the 'shifted baseline' of our understanding of natural conditions leads to unambitious 'Conservation Objectives' for MPAs, where slow-growing, late maturing fish and other seabed species, once 'typical' components of functioning MPA 'features', are often absent or scarce, and are no longer considered or protected.

MPAs can reverse bottom trawl impact

Bottom trawl fishing has had a significant impact on the function and species characteristics of coastal and offshore marine ecosystems. It has affected fish size, and life-history strategies of constituent species (Tillin et al. et al., 2006). Perhaps the greatest ecosystem impact to our offshore shelf seas over the past 120 years, has been to reduce many offshore shellfish and bivalve reefs to low-complexity shell, sand and gravel beds (Thurstan et al., 2013), with the first pass of a demersal trawl or dredge being the most destructive for many habitats such as bivalve reefs (Cook et al., 2013). This has been the case with reduction in populations of horse mussel, oyster, blue mussel and fan mussel beds (Stirling et al., 2016; Solandt, 2003). These were hitherto prominent in coastal and shelf ecosystems, and provided various functions: They provided mechanisms of locking in carbon and

[11] Figures correct on August 2020 - analysis conducted before the designation of the West of Scotland MPA so site was not included.
[12] https://www.sciencedirect.com/science/article/abs/pii/S0025326X17300115

filtering seawater of contaminants and excess nutrients, and acted as a hard habitat base for many species for subsequent colonisation and attachment. Many recovered invertebrate populations have been proven to be important for shellfish recruitment within MPAs that have banned bottom trawls. For example, young scallops settle onto the mesh-like surfaces of bryozoans (Howarth et al., 2015; Bradshaw et al., 2003). Some species of commercially important juvenile fish & shellfish are at higher abundance in more complex seabed habitats (Elliott et al., 2017), such as cod and scallops.

Figure 1. Bryozoans are significant 'traps' for juvenile scallops. Damage to bryozoans by bottom trawling damages these important species and habitats. (Photo: Hilmar Hinz).

Bottom trawl fishing has impact on natural food webs

Removal of target commercial species leading to resilient fast-growing smaller forms of life, and collateral damage to essential fish habitat and seabed complexity are major effects of seabed trawling. We have also fished down the food chain and started to exploit the species that large fish used to consume in the historical past (Thurstan and Roberts, 2010). The value and volume of landings of crab, lobster, *Nephrops* and scallops has increased, largely because their predators (cod and large species such as halibut) are reduced to a fraction of their size, biomass and abundance, now with limited ecological function and influence. There is a commercial interest in not seeing a return to cod dominance of the inshore west of Scotland nephrops grounds, largely because cod - in greater more natural densities - are significant consumers of nephrops (Johnson et al., 2013). Hence, it is logical that there may be resistance to fully recovered ecosystems as it may affect the current investment in catching animals (such as nephrops and scallops) that are lower in the foodchain. So natural recovery that could be fostered by MPAs and limits on fishing simply is not in the economic interests of some parts of the fishing industry.

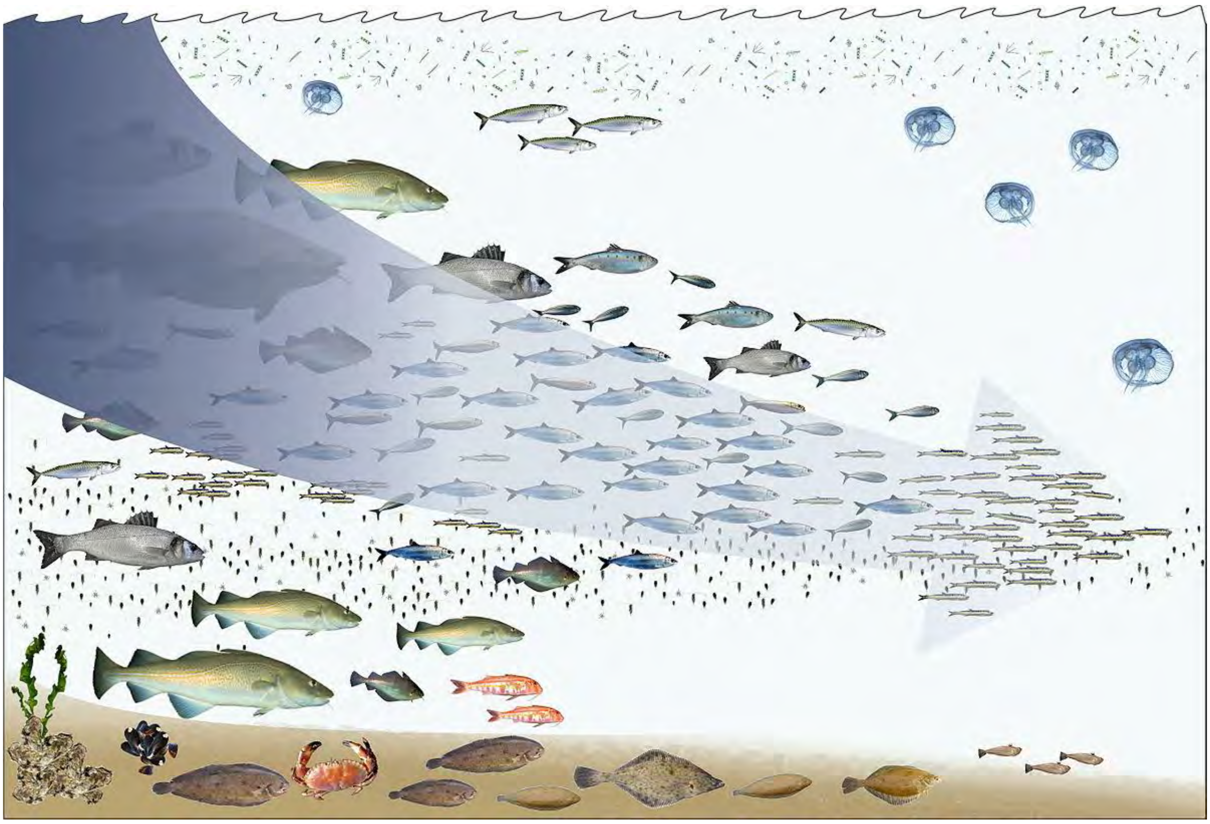


Figure 2. An illustration of how the food chain has been altered by fishing, and how our 'baseline' has shifted to the right. MPAs, if highly protected, or protected from bottom trawling can recover areas back to the biodiversity represented on the left of this image. (after Pauly et al., 1998).

Recovery of the seabed helps fisheries ecology, biomass and economics

Fishing has reduced not only the biomass of the fish available to be captured, but has damaged the seabed habitat complexity and function. Emerging research from some inshore MPAs is revealing that juvenile fish move between different 'mosaics' of habitats (Elliott et al., 2017). Haddock and whiting prefer rich sands and muds in coastal Scottish seas. Codling are more prevalent in seagrass, reefs and complex seabeds relative to flat featureless seabeds. Results from areas closed to scallop dredging over 20 years ago in the Isle of Man showed that scallop spat preferentially settle in areas of high bryozoan densities (Bradshaw et al., 2003). These positive results have all emerged from coastal MPAs from the UK and Isle of Man, and areas closed (for >5 year durations) to bottom towed fishing. We need to expand our understanding of recovery from such management to large, offshore sites.

All marine habitats are represented in our current UK Marine Protected Area network – but these habitats remain largely denuded, degraded, and in some cases hardly reminiscent of their ecological past in many areas of offshore seas. If recovered, such essential fish habitat and constituent benthic species and habitat complexity could support recovery of species by providing the environmental conditions necessary for feeding and shelter of juvenile life stages (e.g. Elliott et al., 2017; Solandt et al., 2019) and provide ecological resilience in the face of climate change. Populations recovering within such protected areas will eventually 'spill-over' to areas outside of MPAs, allowing opportunities for more sustainable harvest (Lorenzo et al., 2016). The 'displacement' argument, whereby MPAs move fishing elsewhere and thereby increase pressure on neighbouring grounds, is often used by commercial sector representatives to argue against exclusion of fishing within MPAs (Vaughan, 2017). However, the 'spill-over effect' has never been offered the opportunity to be proven within UK seas.

Bottom trawl fishing has a negative effect on climate mitigation

Fishing continues to have a negative impact on climate mitigation (Roberts et al., 2017). Biogenic habitat-forming seabed species, including horse mussels, blue mussel beds, flame shell reefs, Sabellaria worm reefs, native oyster beds, fan mussels, coral, bryozoan and hydroid seabeds have all become rare in offshore waters because of decades of bottom trawling (Stirling et al., 2016; Solandt, 2003; Thurston et al., 2013). These species used to live and accrue in vast areas before the advent industrial bottom trawling. An 'oyster reef' in the southern North Sea in the 1880s was described as being the size of Wales, and such habitats were common in coastal areas of eastern Scotland (Farrinas-Franco et al., 2018).

The reduction in living seabed habitats has had a deleterious role in the capacity of our seas to fix and store carbon, both in benthic organisms' shells and tissues, and in the sediment. MPAs can recover the seabed and associated ecosystem services, but not if they are trawled. Recovery can take the form of active restoration for some inshore habitats where it is practical and economic to re-lay habitat, introduce settlement plates and shells for oysters, mussels and other bivalves (Farinas-Franco et al., 2018). Active restoration is currently not financially viable in our vast offshore MPAs. Here the most-effective restorative technique is to simply (and cost-effectively) leave the seabed free from abrasion from bottom towed fishing, and permit habitat-forming species to naturally recruit into MPAs, grow and spread, and then attract other species (Howarth and Stewart, 2014).

Seabed trawling also releases carbon locked in sediments into the water column in dissolved form, that may then be released into the atmosphere over long timescales, contributing to climate change (Luisetti et al., 2019; Pusceddu et al., 2014). Luisetti et al. (2019) estimate that 220 megatonnes (Mt) of carbon is locked into UK seabeds[13]. They estimate that 93% of the UKs marine carbon assets (205Mt) lie within sediments in UK offshore waters where no trawling restrictions apply. The study estimates that between 2016 and 2040, the continuing disturbance to seabed sediments and the resultant release of carbon could cost the UK up to US$12bn in 'abatement costs'[14]. By banning towed fishing gears in MPA sediments we can reduce the amount of carbon emitted through disturbance, and allow recovery of biomass of animals effective at locking down carbon into the seabed (Tillin et al., 2006), further increasing the carbon assets of our seas (Figure 3). Building carbon stocks up, not just preserving them as they are.

[13] In saltmarsh, seagrass meadows, and shelf sediments.
[14] i.e. the cost of mitigating carbon emissions (Luisetti et al. 2019)

Figure 3. A horse mussel reef and associated corals and bryozoans are excellent juvenile fish habitats, and productive environments. Such habitat complexity is now rare in the North Sea: Isolated live shells are found on the Dogger Bank. They are common in an area between Denmark and Sweden that has been protected from trawling for 90 years (The Oresund). (Image: Dr Rohan Holt).

The law and governance of fishing in offshore MPAs

Implementation of fisheries management measures in UK offshore MPAs has been governed by EU laws since sites were formally designated (Appleby & Harrison, 2019). Prior to Brexit, the UK had attempted to implement management measures that were either rejected or diminished by other member states with a declared fishing interest in UK sites under the EU Common Fisheries Policy (CFP) (e.g. Dogger Bank process – Parramore, 2020; Appleby et al. 2020).

Biodiversity conservation and fisheries management have been siloed separately - as if they are mutually exclusive (Friedman et al., 2018). Within the European Commission, the fisheries directorate (DG Mare) is legally tasked with implementing fisheries management measures to protect biodiversity, acting on the advice of the Environment Directorate (DG Environment). Many EU states (particularly the Netherlands, France, Belgium and Spain) fish some UK offshore MPAs more intensively than UK vessels, so there has been political reluctance for those nations to stop fishing in our productive offshore waters – be that inside or outside UK MPAs. In Scotland, management measures for offshore nature conservation Marine Protected Areas and Special Areas of Conservation – developed by Marine Scotland with industry and NGO input in 2015 – were submitted to the CFP process, but no "Joint Recommendations" have yet been forthcoming. As such the CFP Article 11 process that requires 'Joint Recommendations' for managing fishing in UK offshore MPAs has failed to deliver a single measure to protect a single site.

As such – up until the present – no UK offshore MPA has been made subject to management measures to prevent damaging fishing other than the Darwin Mounds SAC that achieved emergency protection for fragile deep-water corals in 2003-2004 after a legal challenge by an NGO.

The MMO (Marine Management Organisation) is tasked with applying management measures to English offshore MPAs to meet Conservation Objectives of each site. Since offshore marine conservation is executively devolved, Marine Scotland is responsible for developing proposals for designation and management measures for SACs and nature conservation MPAs in Scotland's offshore waters. Similarly, in Wales, the Welsh Government has authority to designate and manage offshore sites. The Joint Nature Conservation Committee provides advice on operations needed to meet Conservation Objectives in Welsh and English waters for consideration by the MMO, whilst JNCC, NatureScot and Marine Scotland Science provide advice to Marine Scotland. Northern Ireland offshore waters are managed by Defra and the MMO with advice on conservation issues from JNCC. On leaving the EU, respective UK fisheries authorities will then have unilateral responsibility to protect offshore MPAs in their respective jurisdictions, for the good of the seas, climate change, productivity, and providing greater food security.

In this report we illustrate how much our offshore MPAs are being fished, and provide cost estimates to the carbon sequestration capacity of our marine environment. MCS used publicly available information (Global Fishing Watch[15]) that tracks fishing fleet activity by tracking the satellite signals from large-scale fishing vessels. EU regulations have specified that over 15m long EU-registered fishing vessels are required to hold on-board AIS (Automatic Identification System) signals for reasons of safety. The purpose of this report is to show – with this technology – which countries fish in which UK offshore MPAs, and how this activity renders our MPAs as meaningless 'paper parks' where no management occurs. Brexit can be taken as an opportunity to simplify fisheries management measures for MPAs in offshore UK waters. Respective fisheries authorities can use the powers in the Fisheries Act 2020 to put in place management measures that ensure MPAs contribute to return our seas to productivity whilst mitigating some of the effects of climate change.

[15] https://globalfishingwatch.org/

Method

Using fishing effort data for bottom trawling, dredging and demersal seining provided by Global Fishing Watch (GFW) (https://globalfishingwatch.org/datasets-and-code/) we conducted an overlay analysis with MPA boundary data to ascertain the quantity and distribution of fishing activity inside and outside UK offshore MPAs between 2015 and 2018. For this analysis, we included the 49 UK MPAs[16] that met the following criteria:

1. Designated for at least one seabed feature[17]
2. Have part or all their boundary within UK offshore waters (between 12-200 NM off the UK coastline)
3. Proposed as a Site of Community Importance (henceforth termed "designated") before or during 2018 (20 Marine Conservation Zones were omitted as they were designated in 2019).

For sites that were designated during the 2015-18 period, fishing effort is worked out as of the year they were designated (e.g. if a site was designated in 2016, fishing effort recorded in 2015 has not been included in the total effort). We then applied this same analysis to the 20 offshore Marine Conservation Zones designated in 2019 in order to quantify fishing activity prior to designation[18]. At the time of writing, the West of Scotland MPA had not been designated so has not been included in this analysis.

GFW process vessel tracking data collected from Automatic Identification Systems (AIS), using two "convolutional neural networks" to extract only apparent fishing activity[19] (data excludes steaming activity) and vessel characteristics (e.g. fishing gear in use) (Kroodsma et al., 2018). This global fishing effort dataset is provided by vessel in 0.1° x 0.1° resolution (~11km x 11km squares) and can be cross-referenced with the GFW vessel dataset to extract activity by gear type. GFW have only published effort data for 2015-16, however, for the purpose of this analysis, we sought data from their provisional dataset as this allowed us to analyse data for the entire 2015-18 period. We note that there is less than 3% difference between the total fishing hours recorded in the published 2015 and 2016 data compared to the provisional data for the area studied. We used a combination of *Google BigQuery*[20] and *R x64 3.6.3*[21] to extract the data. For the purpose of this analysis, we used "trawler", "dredge_fishing" and "other_seine" GFW gear categories to extract fishing effort data. As it was not possible to distinguish between demersal and pelagic towed gear particularly within GFW's 'trawler' category, we cross-referenced the GFW vessel dataset further with the EU fishing fleet register to extract data only for those vessels registered using demersal towed gear (Vespe et al. 2016).

We compiled a list from the publicly available EU fleet register[22] of all the vessels registered as using demersal towed gear (i.e. trawls, dredges and seines only) as of the 1st January of each year studied (2015-2018) (see appendix for full list of gears included). We cross-referenced the respective lists with both the GFW fishing vessel list (to identify the GFW gear category) and provisional fishing effort data

[16] 14 Marine Conservation Zones, 22 SACs and 13 Nature Conservation MPAs. SACs designated for harbour porpoises were not included in this analysis.
[17] Reefs (EU habitats code 1170), Sandbanks which are slightly covered by sea water all the time (EU habitats code 1110), Submarine structures made by leaking gases (EU habitats code 1180).
[18] See Appendix for map of all offshore SACs, MCZs and ncMPAs designated for benthic features.
[19] https://globalfishingwatch.org/faqs/how-accurately-does-gfw-identify-fishing-activity/ (accessed 14/08/2020)
[20] https://bigquery.cloud.google.com/
[21] https://cran.r-project.org/bin/windows/base/old/3.6.3/
[22] https://webgate.ec.europa.eu/fleet-europa/search_et/ (accessed 04/08/2020)

in order to extract demersal fishing activity recorded as fishing hours between 2015 and 2018. The pre-2015 data was omitted from analysis as there was no legal obligation to use AIS equipment on EU vessels (>15 m) prior to 2015[23], thus coverage is limited.

To ensure we only extracted demersal fishing activity data, vessels registered as using pelagic trawl gear instead of or in addition to demersal trawls, dredges and seines were rejected from the look-up list (see Tables 1 and 2 for the number of vessels included). Across the four years studied, on average 3,424 vessels registered using at least one form of demersal towed gear were excluded from analysis due to also being registered users of pelagic towed gear equating to around 26% of the EU's demersal fleet. This, together with the fact many smaller vessels are overlooked by GFW data (Dureuil et al., 2018) analysis is likely to present a contracted estimate of the true volume of towed gear use in offshore waters. That being the case, the number of vessels included in the analysis represents 77-79% of the vessels in the EU fleet register that are over 15 m in length. Furthermore, the study area focuses on offshore waters where small boats operate less frequently. Therefore, we believe the GFW data provide sufficient insight to highlight the presence and extent of fishing inside offshore MPAs around the UK.

Table 1. Number of vessels included in the analysis. Vessels were included in the analysis if they were registered using bottom-contacting mobile gear in the absence of pelagic mobile gear. Data is presented as both total number of vessels and number of vessels according to vessel length.

		All qualifying vessels (demersal trawlers, dredgers and seiners)		By vessel length				
		TOTAL no. vessels	**% EU fleet (all lengths)**	*<10m*	*10-12m*	*12-15m*	*≥15m*	**% EU fleet (≥15m)**
2015	**EU fleet**	*10,242*	-	3,394	1,333	2,038	3,477	-
	EU fleet x GFW ("DREDGE_FISHING")	*233*	2.3%	23	24	16	170	4.9%
	EU fleet x GFW ("TRAWLERS")	*2,747*	26.8%	29	74	159	2,485	71.5%
	EU fleet x GFW ("OTHER_SEINE")	*24*	0.2%	-	-	-	24	0.7%
	EU fleet x GFW (above combined)	*3,004*	*29.3%*	*52*	*98*	*175*	*2,679*	*77.0%*
	UK EEZ	*684*	6.7%	4	21	44	615	17.7%
2016	**EU fleet**	*9,920*	-	3,310	1,303	2,001	3,306	-
	EU fleet x GFW ("DREDGE_FISHING")	*232*	2.3%	23	25	20	164	5.0%
	EU fleet x GFW ("TRAWLERS")	*2,611*	26.3%	29	72	163	2,347	71.0%
	EU fleet x GFW ("OTHER_SEINE")	*24*	0.2%	-	-	-	24	0.7%
	EU fleet x GFW (above combined)	*2,867*	*28.9%*	*52*	*97*	*183*	*2,535*	*76.7%*
	UK EEZ	*684*	6.9%	3	22	52	607	18.4%
2017	**EU fleet**	*9,776*	-	3,309	1,288	1,950	3,229	-
	EU fleet x GFW ("DREDGE_FISHING")	*232*	2.4%	23	25	20	164	5.1%
	EU fleet x GFW ("TRAWLERS")	*2,611*	26.7%	29	72	163	2,347	72.7%
	EU fleet x GFW ("OTHER_SEINE")	*24*	0.2%	-	-	-	24	0.7%
	EU fleet x GFW (above combined)	*2,867*	*29.3%*	*52*	*97*	*183*	*2,535*	*78.5%*
	UK EEZ	*684*	7.0%	4	23	50	607	18.8%
2018	**EU fleet**	*9,631*	-	3,344	1,239	1,910	3,138	-
	EU fleet x GFW ("DREDGE_FISHING")	*225*	2.3%	29	22	18	156	5.0%
	EU fleet x GFW ("TRAWLERS")	*2,537*	26.3%	30	73	152	2,282	72.7%
	EU fleet x GFW ("OTHER_SEINE")	*26*	0.3%	-	-	-	26	0.8%
	EU fleet x GFW (above combined)	*2,788*	28.9%	59	95	170	2,464	78.5%
	UK EEZ	*643*	6.7%	8	22	44	569	18.1%

EU Fleet: *Number of vessels that met the criteria (registered using bottom-contacting mobile gear in the absence of pelagic mobile gear)*

EU fleet x GFW: *Number of vessels from the EU fleet that met the criteria, had enough information provided to cross reference with the GFW vessel database, and the gear category GFW assigned them.*

UK EEZ: *Number of vessels from the lookup that were active inside the UK's EEZ in each year*

[23] COUNCIL REGULATION (EC) No 1224/2009: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32009R1224&from=EN

Table 2. Number of the qualifying vessels that were registered using demersal seine nets instead of, or in addition to demersal trawling and/or dredging gear. Data is presented as both total number of vessels and number of vessels according to vessel length.

		Number of qualifying vessels using seines *(instead of or in addition to trawls/dredges))*		By vessel length				
		TOTAL no. vessels	**% EU fleet (all lengths)**	*<10m*	*10-12m*	*12-15m*	*≥15m*	**% EU fleet (≥15m)**
2015	**EU fleet**	*1,105*	-	810	141	59	95	-
	EU fleet x GFW ("DREDGE_FISHING")	-	0.0%	-	-	-	-	0.0%
	EU fleet x GFW ("TRAWLERS")	*51*	4.6%	1	2	4	44	46.3%
	EU fleet x GFW ("OTHER_SEINE")	*22*	2.0%	-	-	-	22	23.2%
	EU fleet x GFW (above combined)	*73*	*6.6%*	*1*	*2*	*4*	*66*	*69.5%*
	UK EEZ	*37*	3.3%	-	-	-	37	38.9%
2016	**EU fleet**	*1,081*	-	797	136	59	89	-
	EU fleet x GFW ("DREDGE_FISHING")	-	0.0%	-	-	-	-	0.0%
	EU fleet x GFW ("TRAWLERS")	*44*	4.1%	-	2	4	38	42.7%
	EU fleet x GFW ("OTHER_SEINE")	*22*	2.0%	-	-	-	22	24.7%
	EU fleet x GFW (above combined)	*66*	*6.1%*	-	*2*	*4*	*60*	*67.4%*
	UK EEZ	*35*	3.2%	-	-	-	35	39.3%
2017	**EU fleet**	*1,069*	-	794	139	54	82	-
	EU fleet x GFW ("DREDGE_FISHING")	-	0.0%	-	-	-	-	0.0%
	EU fleet x GFW ("TRAWLERS")	*44*	4.1%	-	2	4	38	46.3%
	EU fleet x GFW ("OTHER_SEINE")	*22*	2.1%	-	-	-	22	26.8%
	EU fleet x GFW (above combined)	*66*	*6.2%*	-	*2*	*4*	*60*	*73.2%*
	UK EEZ	*24*	2.2%	-	-	-	24	29.3%
2018	**EU fleet**	*1,076*	-	803	138	55	80	-
	EU fleet x GFW ("DREDGE_FISHING")	-	0.0%	-	-	-	-	0.0%
	EU fleet x GFW ("TRAWLERS")	*45*	4.2%	1	3	4	37	46.3%
	EU fleet x GFW ("OTHER_SEINE")	*24*	2.2%	-	-	-	24	30.0%
	EU fleet x GFW (above combined)	*69*	*6.4%*	*1*	*3*	*4*	*61*	*76.3%*
	UK EEZ	*18*	1.7%	-	-	-	18	22.5%

EU Fleet: *Number of vessels that met the criteria (registered using demersal seine gear in the absence of pelagic seine gear)*

EU fleet x GFW: *Number of vessels from the EU fleet that met the criteria, had enough information provided to cross reference with the GFW vessel database, and the gear category GFW assigned them.*

UK EEZ: *Number of vessels from the lookup that were active inside the UK's EEZ in each year*

In addition, by using AIS tracking data as processed by GFW rather than that sought from VMS, the effort data allows us to not only measure actual fishing activity, but also the national fleet composition of the total effort (see Figure 4) and the proportion of the MPA’s area that has been subject to fishing. We have presented the data here as cumulative fishing effort combining the hours fished inside MPA boundaries throughout the study period. An annual breakdown of total fishing hours in each MPA between 2015 and 2018can be found in the Appendix.

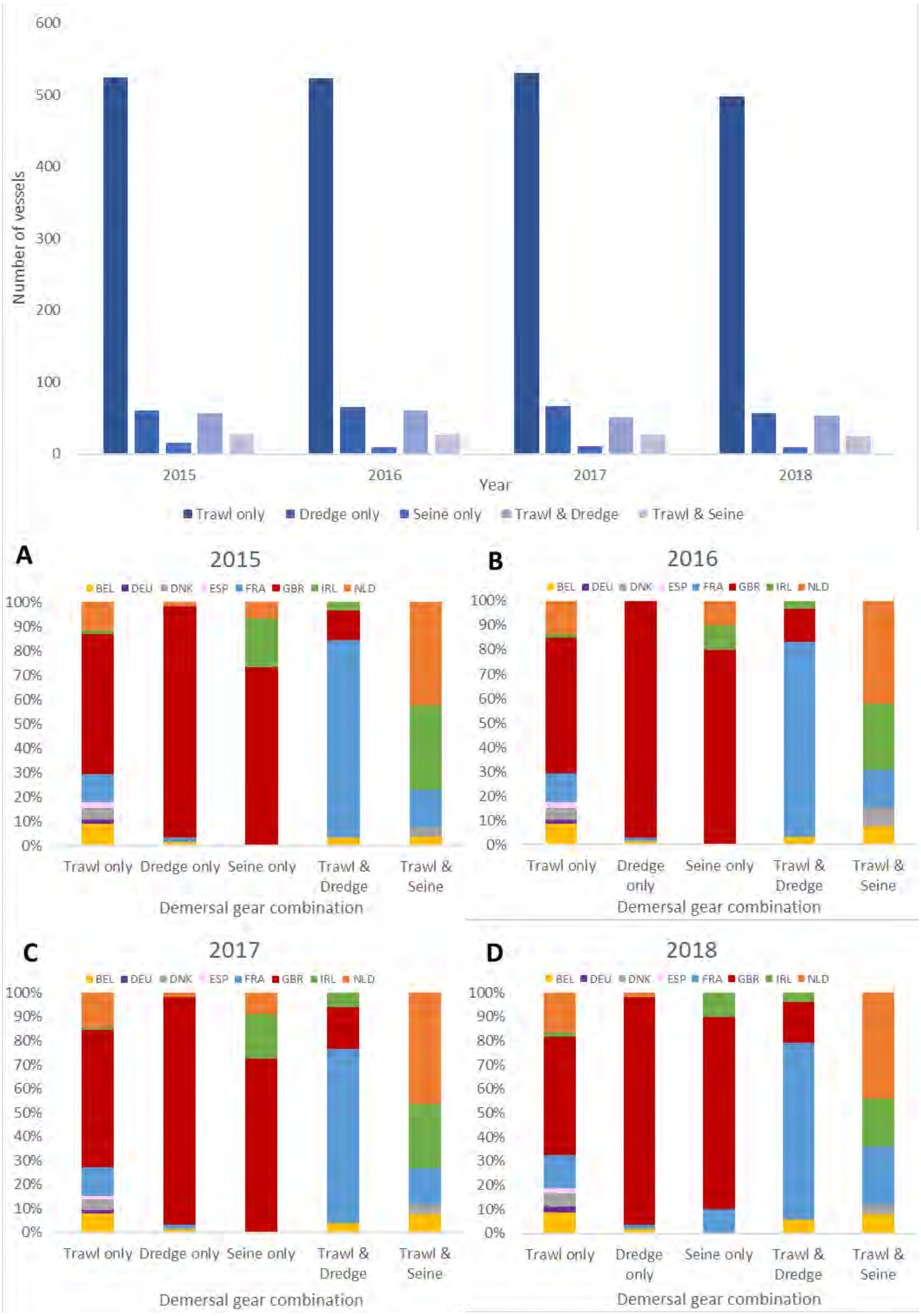


Figure 4. Number of vessels active in the UK EEZ registered using towed demersal gear (graph A) and the National fleet composition of these vessels defined by gear category (graphs B-E) between 2015-18.

Blue Carbon metrics

We approximated the amount of carbon stored within offshore benthic MPAs with shelf sediment (n=60) in depths up to 200 m and the economic cost of the disturbance of this carbon using metrics from Luisetti et al (2019). With EUNIS A5 habitat data from the 2018 UKSeaMap[24], we determined the proportion of shelf-sediment habitat shallow continental shelf waters (<200 m depth - as per Luisetti et al) within these MPAs, and applied this as a proportion of the 205Mt carbon Luisetti et al (2019) describe as being stored in UK shelf sediment. In order to determine the economic cost of losing this carbon through anthropogenic disturbance, we derived the proportion of EUNIS A5 shelf sediment habitat within offshore MPAs that experienced fishing between 2015 and 2018. We then applied this proportion to the US$12bn (Luisetti et al., 2019) abatement cost that carbon emissions from the disturbance of carbon in shelf sediments will cost over a 25-year period (assuming increased pressures from climate change and human activities). These values represent the cost of the measures and policies that would need to be implemented to mitigate the carbon emissions released from sediments disturbed by trawls, and are presented in pound sterling[25]. All calculations can be found in the Appendices.

All spatial analysis was completed using *ArcPro 2.5.0*[26] and *QGIS 2.8.3*[27] and statistical analysis undertaken using *Microsoft Excel 2016*[28].

[24] https://jncc.gov.uk/our-work/marine-habitat-data-product-ukseamap/
[25] Conversion rate of £0.76 to US$1 (11 November 2020).

[26] https://www.esri.com
[27] https://www.qgis.org
[28] https://www.microsoft.com/

Results

Error! Reference source not found.5 illustrates the cumulative pan-UK distribution of fishing hours recorded between 2015 and 2018. From this it can be noted that there are distinct hotspots of towed demersal gear usage off the South-West and South-East coasts of England, around the Isle of Man, and in the North Sea. In many of these areas, total cumulative fishing hours recorded inside MPA boundaries are in excess of 1,000 hours during the four-year period. Between 2015 and 2018, 48.98% of the MPAs designated before 2018 (n=49) experienced over 1,000 hours of demersal fishing with 12.24% being subjected to over 5,000 hours of demersal fishing. Our analysis found that the *Anton Dohrn Seamount* SAC was the only MPA not to experience any demersal fishing activity by the vessels included between 2015 and 18.

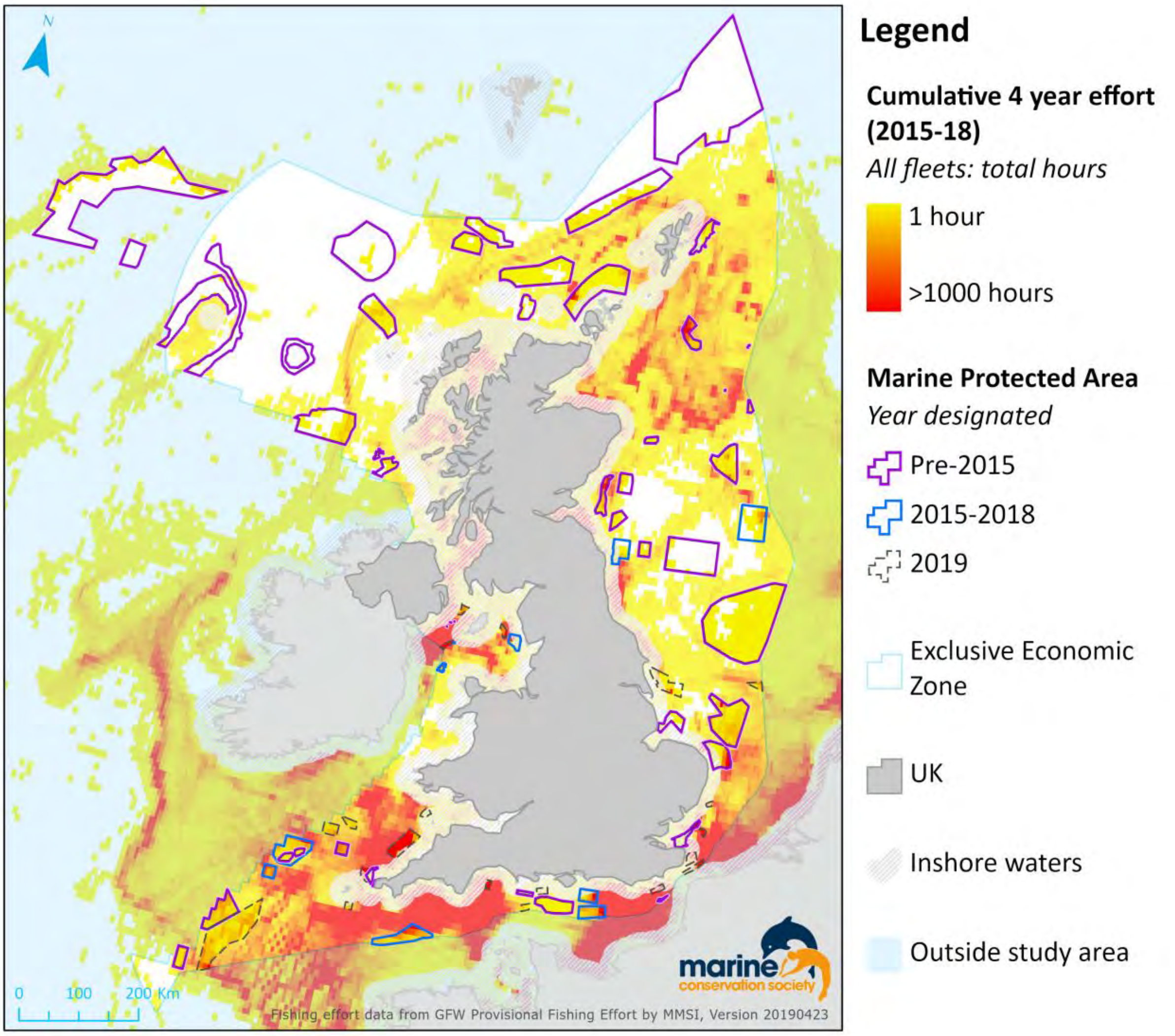


Figure 5. Total cumulative fishing hours inside and outside UK offshore MPAs for the period 2015-18. Fishing effort data from GFW Provisional Fishing Effort by MMSI, Version 20190423 is presented in 0.1°x0.1° resolution (~11km^{2}x11km^2). See Appendix for larger version.

Fishing inside MPAs compared to outside between 2015 and 2018

Between 2015 and 2018, the sandbanks and reefs offered 'protection' by the UK's offshore MPAs have experienced a total of nearly 89,900 hours (equivalent to 3,746 days) of fishing effort by vessels using bottom-contacting mobile gear. Such fishing accounted for at least 4.4% of total fishing effort conducted by the vessels analysed (Table 3); a figure that represents only a small proportion of the true extent of fishing by the UK and other EU fleets.

Table 3 Total fishing inside and outside UK offshore Marine Protected Areas between 2015 and 2018. Data from Global Fishing Watch's provisional fishing effort by vessel dataset (2012-2018).

	Total fishing hours	Proportion of total effort (%)	Fishing rate (hrs/km^2)
Effort inside MPAs[1]	89,893.86	4.35%	1.21
Effort outside MPAs[2]	1,978,758.30	95.65%	5.62
Effort within EEZ	2,068,652.16	-	4.98

Metrics worked out for the "trawlable area" of the EEZ defined as within 0-800m depth (in line with EU ban on trawling below 800m)
[1] Effort that occurred within MPA boundaries between 2015 and 2018, or as of the designation year if they were designated after 2015
[2] Outside MPA boundaries as of the year they were designated - rate worked out using an average "outside MPA" area size

A comparison between UK fishing and other fleets

Over the four-year period, the UK fleet was responsible for 42.65% of all demersal fishing effort recorded inside MPA boundaries (Figure 6A and **Error! Reference source not found.**4), with other EU fleets making up 57.35% of fishing. In contrast, the UK fleet constituted 62.71% of fishing outside MPAs whilst other fleets were responsible for 37.29% (Figure 66B and **Error! Reference source not found.**4).

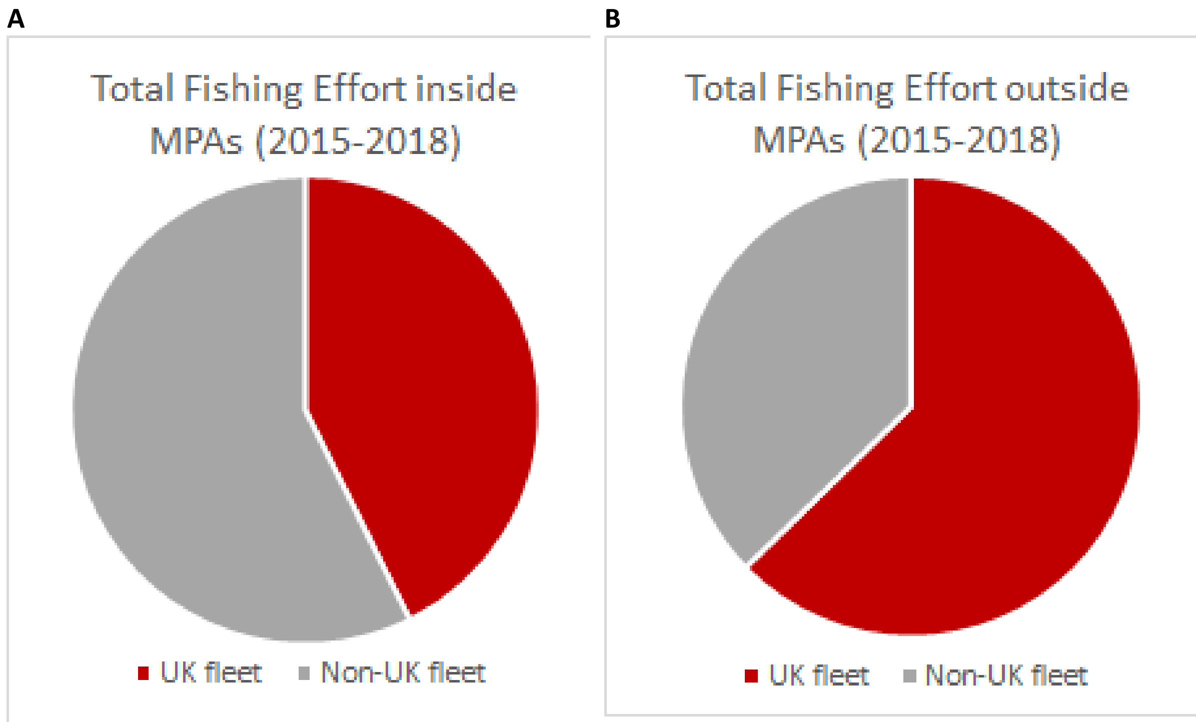


Figure 6. Proportion of cumulative fishing effort in hours recorded inside (A) and outside (B) offshore Marine Protected Areas conducted by the UK fleet in comparison to other fleets between 2015-2018.

Table 4. Cumulative fishing hours and fishing rate recorded inside and outside MPAs between 2015-2018 for the UK and other fleets corrected for site designation date.

		TOTAL FISHING HOURS			*FISHING RATE (hrs/km²)*		
Location	Area (km²)	**All fleets**	**UK fleet**	**Other fleets**	**All fleets**	**UK fleet**	**Other fleets**
Inside MPAs	74,265.12	89,893.86	38,341.00	51,552.86	1.21	0.52	0.69
Outside MPAs	351,821.62	1,978,758.30	1,240,812.72	737,945.58	5.62	3.53	2.10
Whole offshore EEZ	415,638.25	2,068,652.16	1,279.153.72	789,498.44	4.98	3.08	1.90

The footprint of the UK fleet's fishing activity is, in areas, spatially distinct from that of other fleets as shown in Figure 7 and 8. Most notable is the activity in the northern North Sea and the offshore MPAs located there, all of which are ncMPAs in offshore Scottish waters, where the UK fleet are responsible for more of the fishing effort (Figure 7). Similarly, the UK fleet operate heavily alongside other fleets off the south coast of Devon and Cornwall. By comparison, other EU fleets are most active in the English Channel as well as off the north coast of Cornwall and Devon (Figure 8).

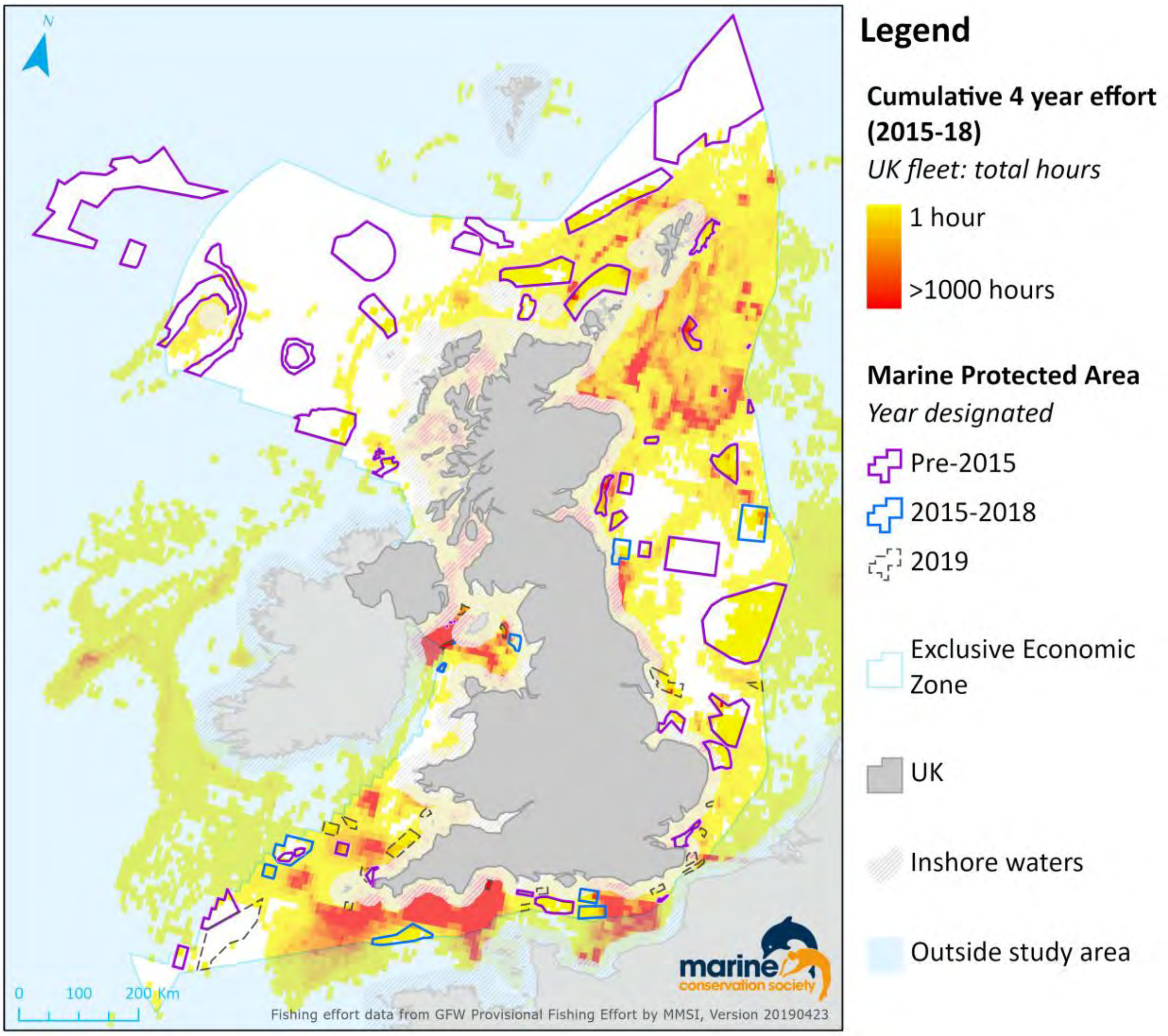


Figure 7. Cumulative fishing effort recorded between 2015 and 2018 defined by the UK fleet. Fishing effort data from GFW Provisional Fishing Effort by MMSI, Version 20190423 is presented in 0.1°x0.1° resolution (~11km²x11km²). See Appendix for larger version.

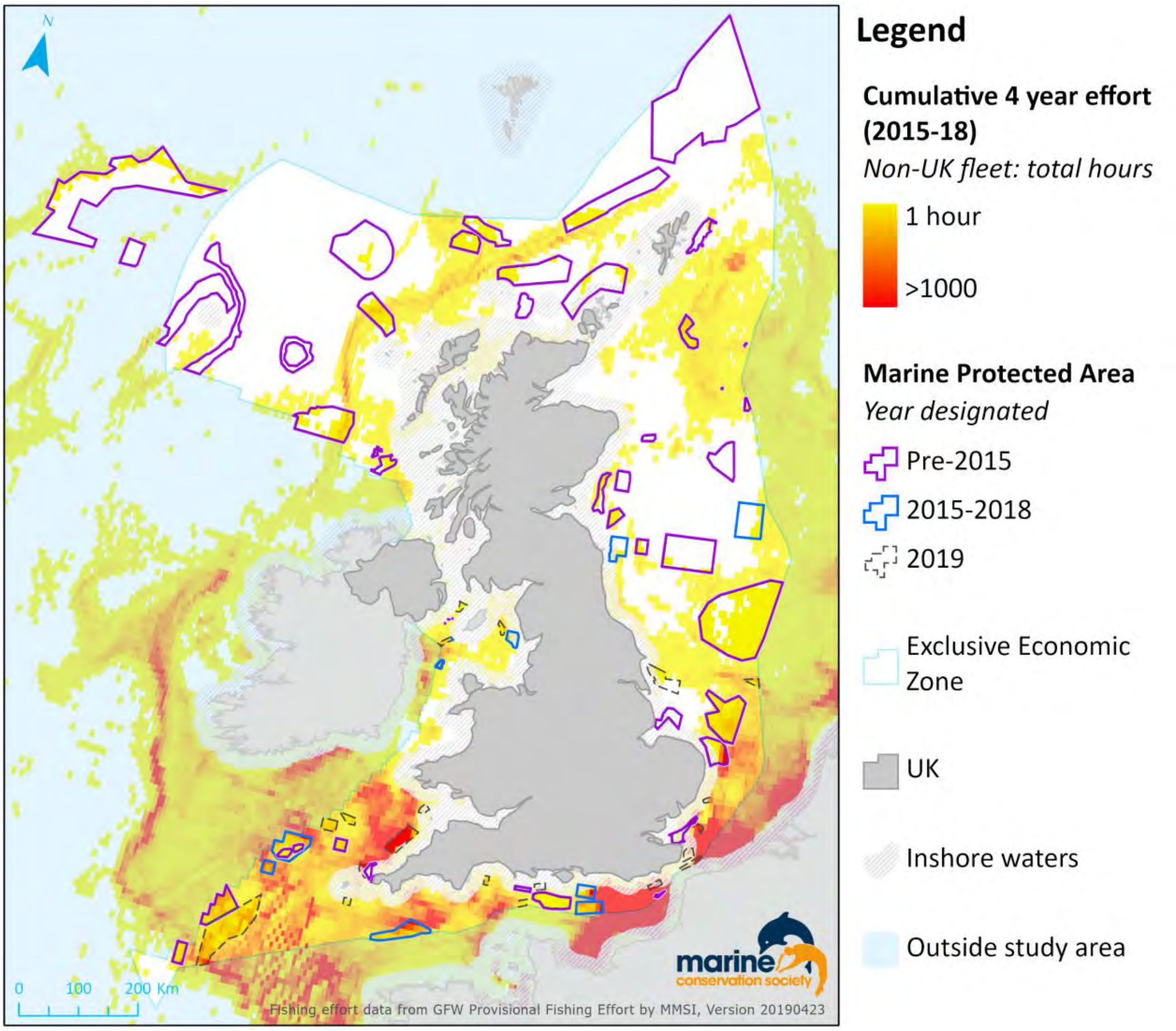


Figure 8. Cumulative fishing effort recorded between 2015 and 2018 defined by other EU fleets. Fishing effort data from GFW Provisional Fishing Effort by MMSI, Version 20190423 is presented in 0.1°x0.1° resolution (~11km^{2}x11km^2). See Appendix for larger version.

Cumulative fishing rates ranged from <1 hr/km^2 up to 8.88 hrs/km^2 [29]. *Central Fladen ncMPA* experienced the highest fishing rate throughout the period followed by *Margate and Long Sands* SAC and *Haisborough, Hammond and Winterton* SAC (Figure 9). Our analysis found that, over the four-year study period, between 95-100% of the surface area of these three sites have experienced some level of demersal fishing, although the distribution of fishing activity varied between sites. From Figure 9 we can see that the national fleet composition varies greatly across the sites that experienced the 10 highest fishing rates with the UK, Belgium, France and the Netherlands being responsible for the greatest proportions of fishing in these 10 areas.

[29] Two MPAs with a surface area less than 100km^2 were excluded in line with the resolution of the effort data (Pisces Reef Complex and Scanner Pockmark SACs)

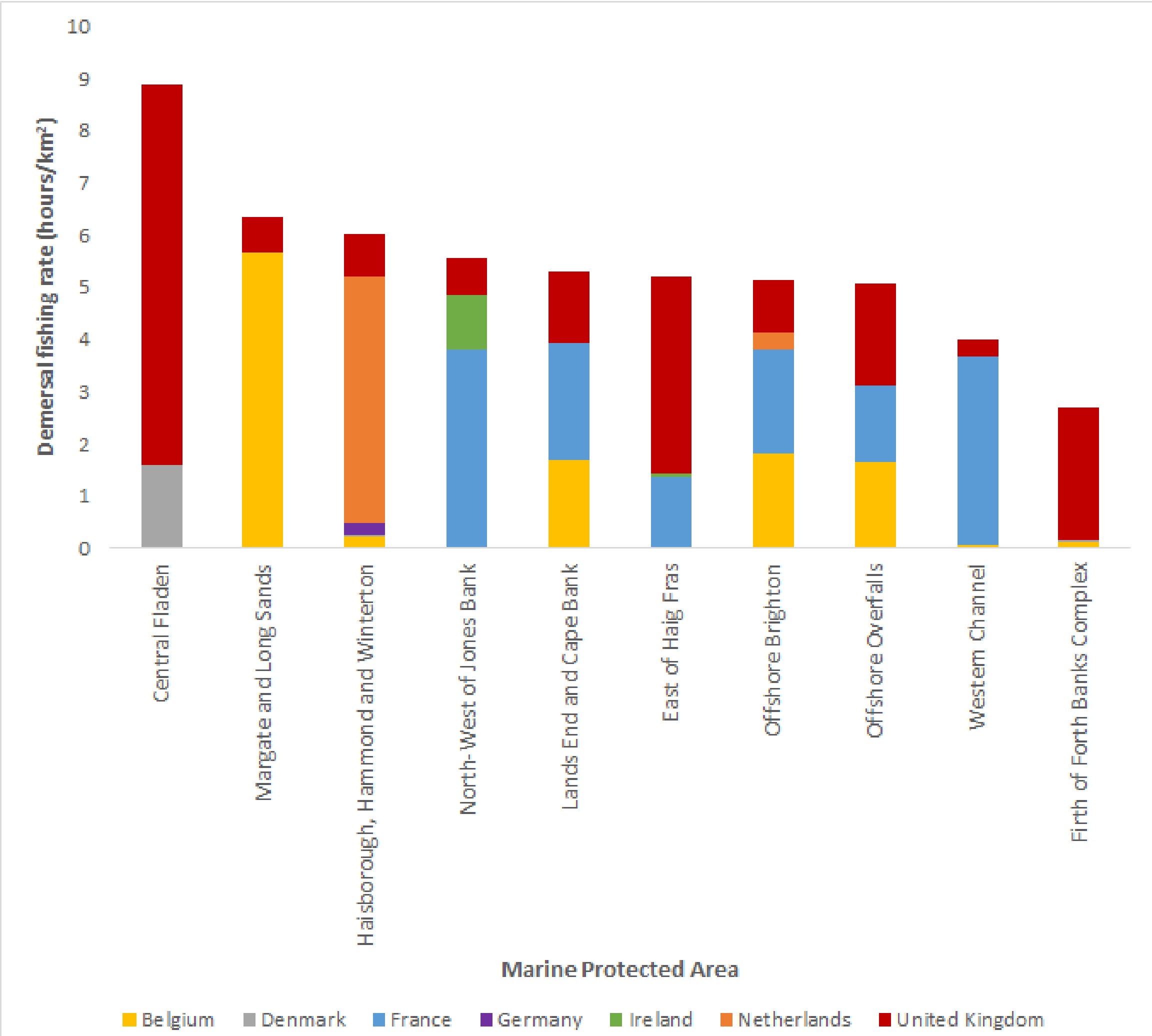


Figure 9. The 10 MPAs with the highest rate of fishing over the 2015-18 period. Data is aggregated for the years between 2015 and 2018. Fishing effort data from GFW Provisional Fishing Effort by MMSI, Version 20190423.

Table 5. MPAs with the top 10 highest fishing rates and the total amount of fishing effort they have experienced between 2015 and 2018. Where sites were designated during the 2015-18 period, effort is worked out as of the year of designation.

Site Code	Site Name	Site Type	Area (km^2)	Year desig.	Total hours.
555560480	Central Fladen	ncMPA	925.19	2014	8212.75
UK0030371	Margate and Long Sands	SAC	639.79	2010	4054.82
UK0030369	Haisborough, Hammond and Winterton	SAC	1468.60	2010	8832.44
UKMCZ0048	North-West of Jones Bank	MCZ	398.19	2016	2218.39
UK0030375	Lands End and Cape Bank	SAC	290.29	2010	1536.93
UKMCZ0023	East of Haig Fras	MCZ	400.07	2013	2086.16
UKMCZ0049	Offshore Brighton	MCZ	862.09	2016	4443.57
UKMCZ0044	Offshore Overfalls	MCZ	594.82	2016	3026.69
UKMCZ0050	Western Channel	MCZ	1614.03	2016	6461.96
555560478	Firth of Forth Banks Complex	ncMPA	2132.12	2014	5752.35

Marine Conservation Zones designated in 2019

When the 20 offshore MCZs designated in 2019 (listed in Table 6) were added to the analysis, we found that these had amongst the highest fishing rates of all the MPAs studied. As shown in Figure 10, half of the 20 offshore MCZs designated in 2019 have historically experienced higher fishing rates than the Top 10 MPAs discussed in the previous section. In fact, *Inner Bank* MCZ, a site designated to protect subtidal sediment habitats off England's south coast[30], saw five times the fishing effort experienced by *Central Fladen ncMPA* (49.02 hrs/km^2 compared to 8.88 hrs/km^2) over the four years studied. Like those sites designated during or before the period studied, Belgium, along with UK vessels constitute a considerable proportion of the fishing activity in these MCZs.

Whilst these MCZs weren't physically designated at the time the fishing effort data used in this study was recorded, with no fishing restrictions established as a result of designation there is no management in place to prevent such high rates of fishing activity continuing into the future.

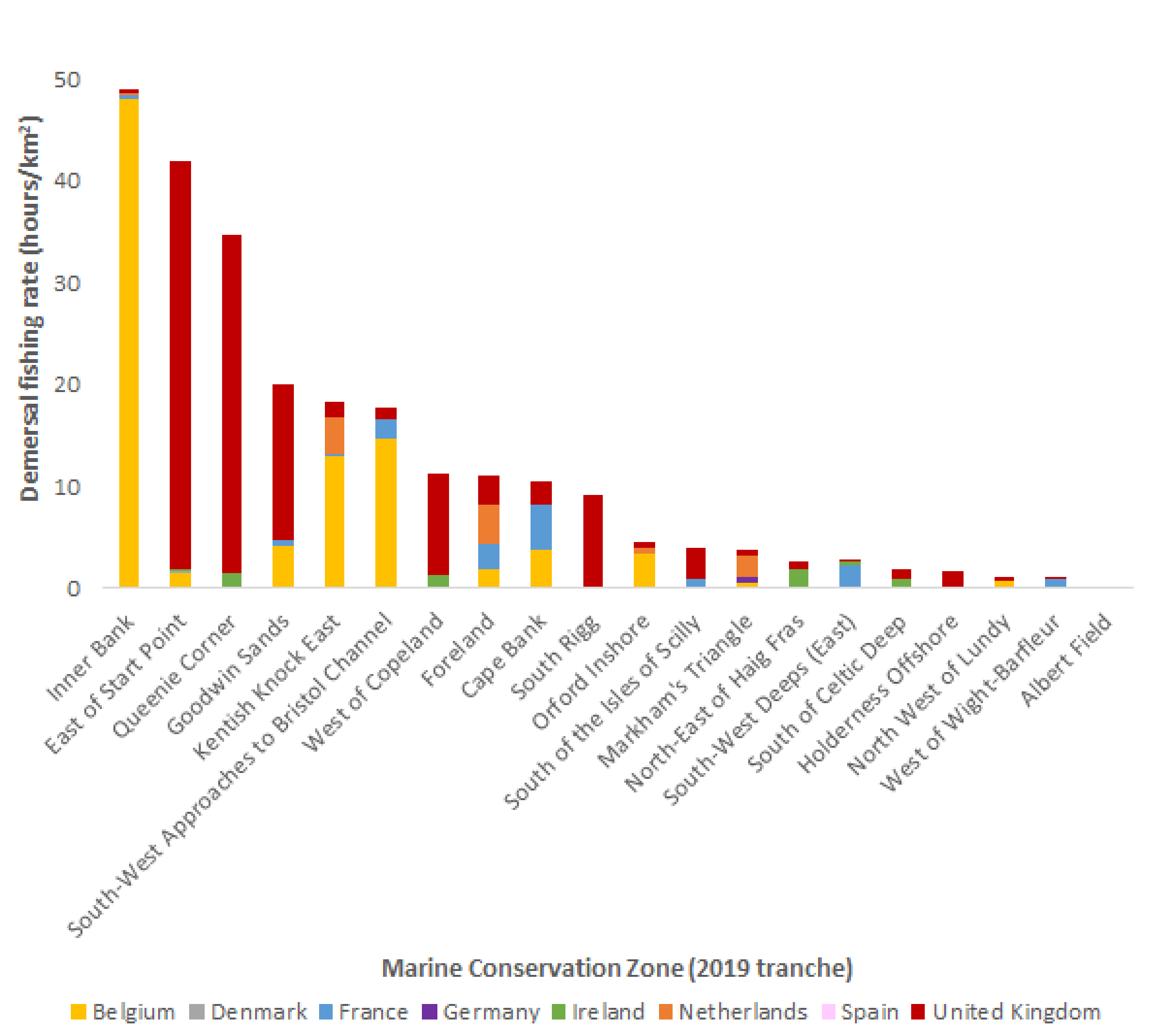


Figure 10. Cumulative fishing effort (2015-18) recorded where Marine Conservation Zones were subsequently designated in 2019.

30 https://consult.defra.gov.uk/marine/consultation-on-the-third-tranche-of-marine-conser/supporting_documents/Inner%20Bank%20Factsheet.pdf

Table 6. The 2019 tranche of Marine Conservation Zones.

Site Code	Site Name	Area (km2)	Year designated
UKMCZ0079	Inner Bank	199.14	2019
UKMCZ0077	East of Start Point	115.55	2019
UKMCZ0086	Queenie Corner	145.95	2019
UKMCZ0061	Goodwin Sands	279.47	2019
UKMCZ0080	Kentish Knock East	96.34	2019
UKMCZ0083	South-West Approaches to Bristol Channel	1128.29	2019
UKMCZ0090	West of Copeland	157.77	2019
UKMCZ0060	Foreland	243.10	2019
UKMCZ0076	Cape Bank	472.56	2019
UKMCZ0088	South Rigg	141.12	2019
UKMCZ0081	Orford Inshore	71.97	2019
UKMCZ0082	South of the Isles of Scilly	132.22	2019
UKMCZ0084	Markham's Triangle	200.15	2019
UKMCZ0085	North-East of Haig Fras	463.84	2019
UKMCZ0089	South-West Deeps (East)	4650.97	2019
UKMCZ0087	South of Celtic Deep	278.25	2019
UKMCZ0078	Holderness Offshore	1176.27	2019
UKMCZ0064	North West of Lundy	173.08	2019
UKMCZ0091	West of Wight-Barfleur	137.63	2019
UKMCZ0051	Albert Field	191.89	2019

Blue Carbon & continental shelf sediments

Carbon stored

Over 64,000 km^2 of shelf sediment habitats are within offshore benthic MPAs. This equates to 12.94% of total UK shelf sediment habitat (EUNIS A5), and consequently, approximately 26.53 Mt of stored carbon. *Dogger Bank SAC* contains the highest proportion of shelf sediment of all MPAs at 2.49% total shelf sediment, followed by *Swallow Sand MCZ* (1.96% total shelf sediment) and *South-West Deeps (East) MCZ* (1.85% total shelf sediment) (Figure 11).

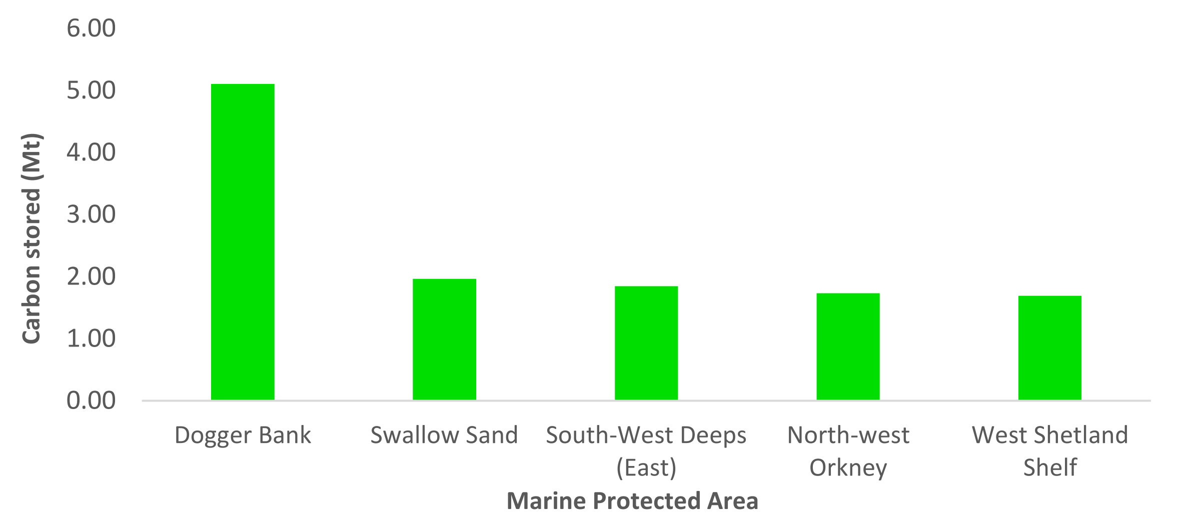


Figure 11. Five MPAs with the highest carbon storage capacity based on data from Luisetti et al (2019). Sediment data from JNCC (EUNIS habitat type A5) for shallow continental shelf waters (<200 m depth) as per Luisetti et al (2019).

Potential carbon disturbance costs

A recent study by Luisetti et al (2019) predicts that the mitigation of increased carbon emissions caused by the disturbance of seabed by trawling activity in UK shelf sea sediments will cost US$12billion over 25 years (2016-2040). Assuming the effort footprint from the 2015-18 GFW demersal fishing data is typical of the area that will continue to be fished over the next 25-years, and based on carbon asset values in 2019 (Luisetti et al, 2019), the mitigation of carbon emissions released by benthic disturbance within offshore MPAs by human activities would cost the UK economy approximately £980 million over 25-years[31], or around £40 million per year. Considering all offshore seabed MPAs, this expense is greatest in *Dogger Bank SAC* where carbon emissions from the continued disturbance of the benthos would cost approximately £200 million to mitigate over the next 25-years, followed by *South-West Deeps (East) MCZ* (£108.1 million) and *North-West Orkney ncMPA* (£100.81 million) (Figure 12).

[31] Equating to 753,569.62 net tonnes of carbon released each year due to trawling (based on metrics in Luisetti et al (2019)).

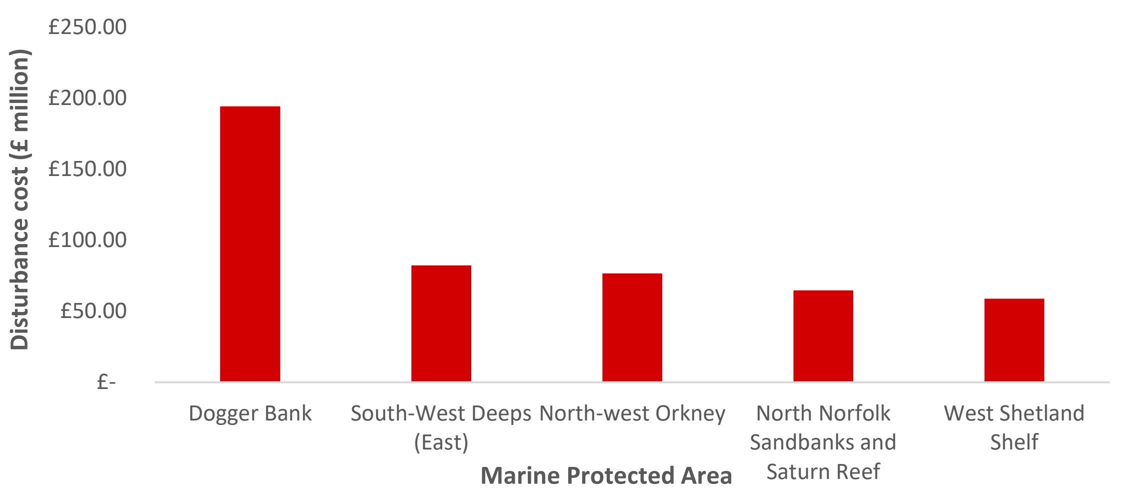


Figure 12. Five MPAs with the highest carbon disturbance economic cost based on data from Luisetti et al (2019). Sediment data from JNCC (EUNIS habitat type A5) for shallow continental shelf waters (<200 m depth) as per Luisetti et al (2019).

The pan-UK distribution of carbon storage and the mitigation costs of carbon emissions from disturbance are shown in Figures 13 and 14.

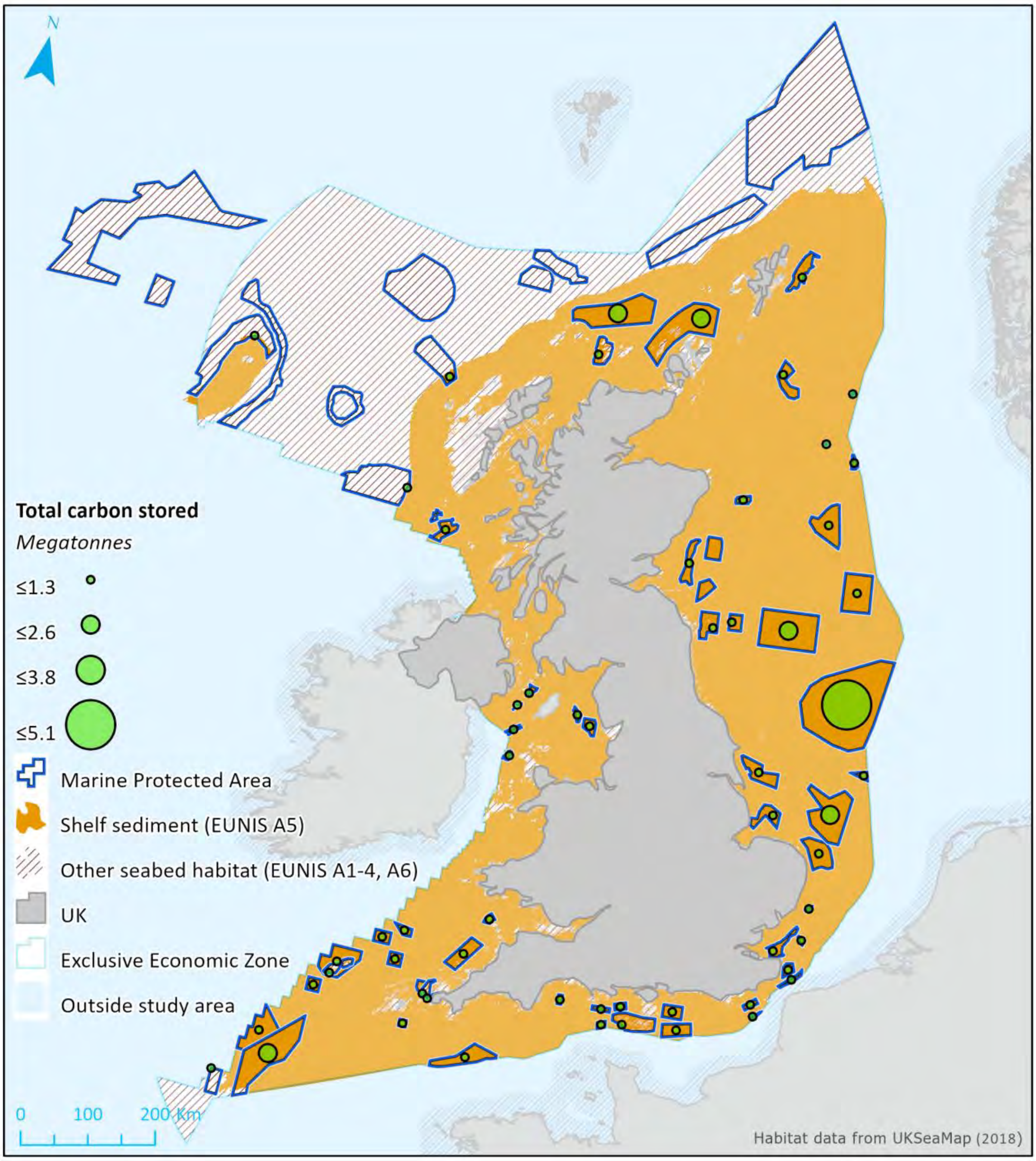


Figure 13. Amount of carbon stored in shelf sediments within offshore benthic MPAs. Magnitude of stored carbon indicated by green circles. Sediment data from JNCC (EUNIS habitat type A5) for shallow continental shelf waters (<200 m depth) as per Luisetti et al (2019).

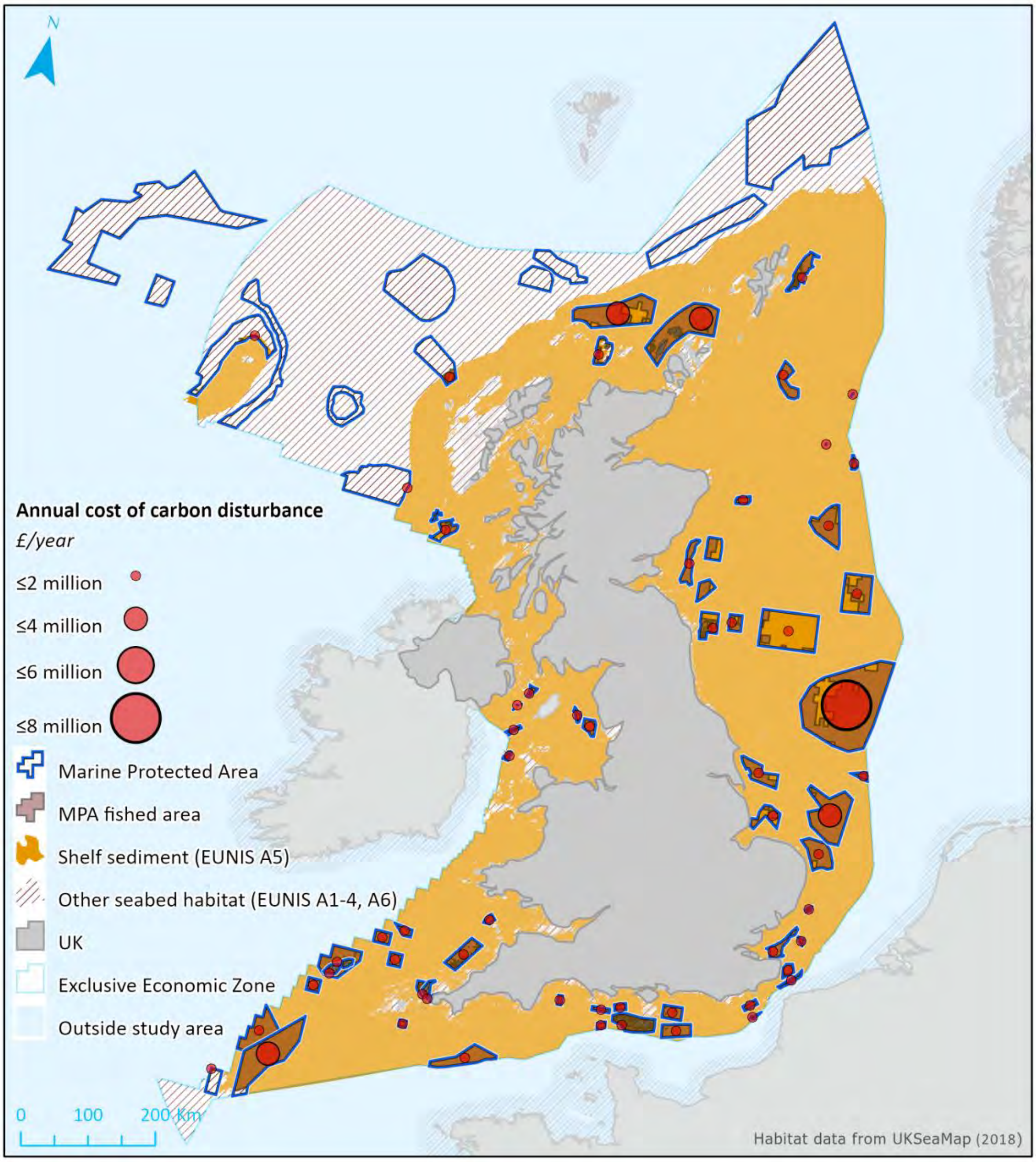
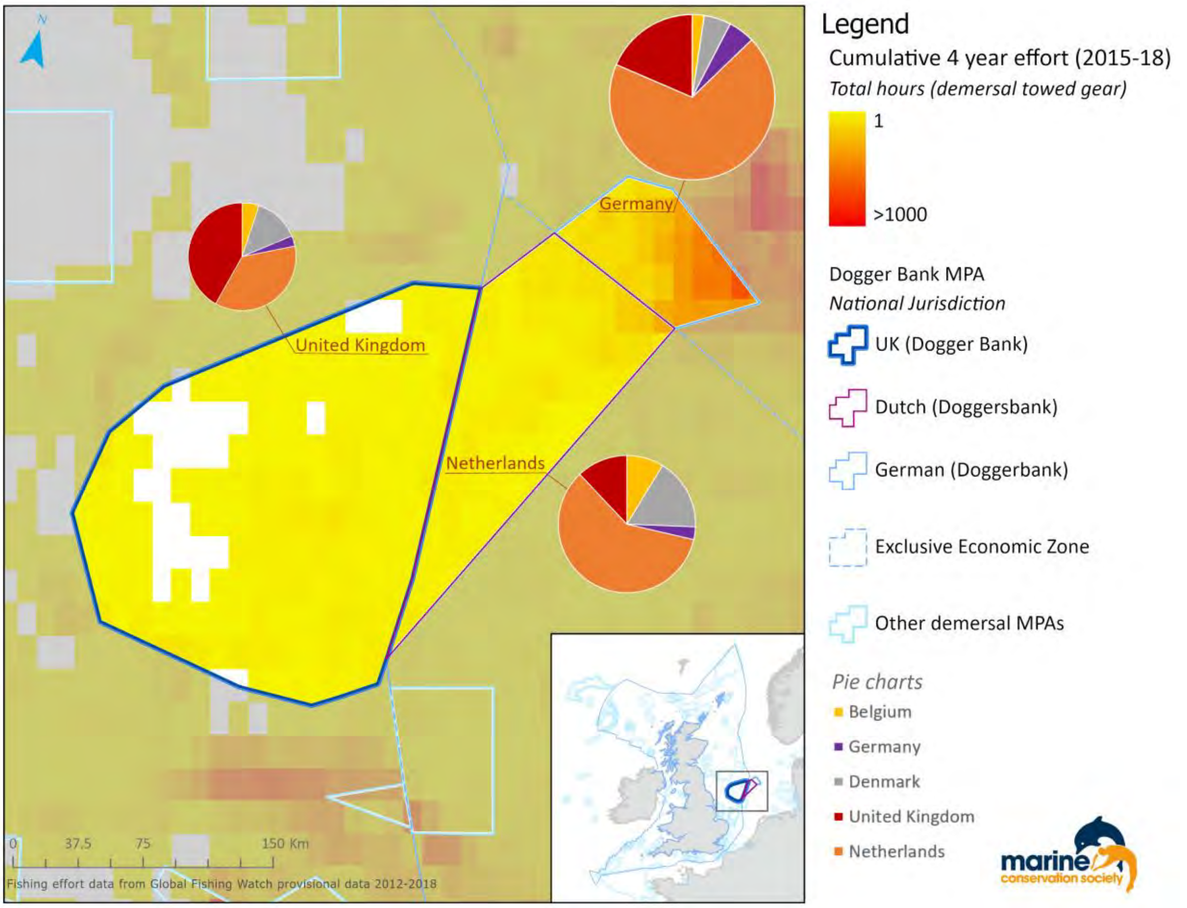


Figure 14. Abatement cost of emissions from the disturbance of carbon stored in shelf sediments within the fished extent of offshore benthic MPAs. Magnitude of cost indicated by red circles. Sediment data from JNCC (EUNIS habitat type A5) for shallow continental shelf waters (<200 m depth) as per Luisetti et al (2019).

Case study: Dogger Sandbank

To provide some further context to the variation in fishing effort and fleet composition, we have focused on the MPAs covering the Dogger Bank. Dogger Bank is a sandbank located in the North Sea spanning the exclusive economic zones of the UK, Netherlands and Germany. As shown in **Error! Reference source not found.**15, the UK part of the *Dogger Bank* SAC experienced the lowest cumulative bottom fishing intensity during the period studied with a total of 2623.41 hours being recorded across 86% of its area between 2015 and 2018 (rate = 0.21 hrs/km^2). The Dutch and German Dogger MPAs experienced comparatively higher fishing rates with a total of 6,202.68 hours recorded across the whole of Germany's *Doggerbank* MPA (rate = 3.66 hrs/km^2) and 2,945.00 hours recorded across the entirety of the Dutch *Doggersbank* MPA (rate = 0.61 hrs/km^2) (Figure 15).

In terms of fleet composition, the Dutch fleet (orange sections of the pie charts in Figure 15) were responsible for the majority of fishing in the German and Dutch MPAs (Figure 15). In the UK section of the sandbank, the UK fleet were responsible for the highest proportion of the effort recorded (41.83%), followed by the Netherlands (36.33%) (Figure 15). The UK fleet also contributed the second highest proportion of the effort recorded in the German section after the Netherlands (18.53%). By comparison, the Danish fleet were responsible for the second highest fishing effort in the Dutch section (16.93%) between 2015 and 2018 (Figure 15).



Site name	Jurisdiction	Year designated	MPA area (km²)	Total fishing hours (2015-18)					Cumulative fishing effort (hours)	Fishing rate (hrs/km²)
				Belgium	Denmark	Germany	Netherlands	United Kingdom		
Doggerbank	Germany	2004	1696.05	145.82	327.56	320.93	4258.81	1149.55	6202.68	3.66
Doggersbank	Netherlands	2008	4792.71	256.35	498.70	87.82	1747.23	354.90	2945.00	0.61
Dogger Bank	United Kingdom	2011	12337.04	133.39	358.10	81.52	953.07	1097.32	2623.41	0.21

Figure 15 Fishing effort recorded inside the MPAs on Dogger Bank and the fleet composition of fishing activity between 2015 and 2018. Effort data from the Global Fishing Watch's provisional fishing effort by vessel dataset is presented in 0.1°x0.1° resolution (~11km^{2}x11km^2). See Appendix for larger version.

Dogger Bank SAC and Blue Carbon

As mentioned, 2.49% of the UK's shelf sediment habitat falls within the UK Dogger Bank SAC boundary. Between 2015 and 2018 this MPA experienced fishing across 86% of its surface area. As a result, its capacity to serve as a blue carbon resource is compromised by the continued disturbance of the benthos by bottom-contacting towed fishing gear. Over the next 25-years (under a scenario of increased climate and human pressures) the continued disturbance of shelf sediment inside the Dogger Bank SAC will cost the UK economy approximately £7 million per year to mitigate (figures derived from Luisetti et al., 2019).

Caveats

Fishing Effort data

The use of GFW data in this analysis does present a contracted estimate of the true volume of towed gear use in offshore waters. This is because vessels smaller than 15 m are greatly underrepresented due to the use of AIS technology only being legally required on larger vessels, and due to the exclusion of vessels registered using pelagic towed gear in conjunction with demersal. These results therefore represent fishing effort for approximately a quarter of the whole EU fleet registered using demersal towed gear in the absence of pelagic as of 1st January of each year analysed. That being the case, using GFW data has enabled us to extract apparent fishing effort for around 80% of qualifying[32] vessels from the EU fleet register that are greater than 15 m. These limitations mean fishing effort is underestimated in our analyses and is likely to be significantly higher.

As published fishing effort data for the 2015-18 period were not available at the time of writing, the data used in this analysis was sought from the GFW's provisional dataset. As a result, there may be some minor changes to the findings once the public data is released. Similar fishing effort data is available derived from VMS vessel tracks. However, this data does not provide insight into the fleet composition of the fishing activity.

Finally, GFW aggregate their fishing effort by vessel data into 11km x 11km area squares thereby protecting the exact location of individual vessels. The relative coarseness of the data, however, does mean that it is difficult to assess total fishing effort within those MPAs with surface areas <100km^2. During analysis, we assumed fishing effort to be distributed equally across the 11km x 11km square and, whilst the majority of MPAs were large enough that the boundary entirely contained cells of fishing effort data, we have adjusted for a disparity in MPA area size and data resolution by excluding smaller MPAs from the results.

Blue Carbon metrics

Using data from Luisetti et al (2019) does mean our Blue Carbon calculations are restricted by the assumptions and limitations described in their study. For example, it is assumed that all the carbon resuspended by trawling is remineralised; a factor based on shelf sea carbon pump models[33] and supported by assumptions made in other studies (Lovelock et al., 2017, Pendleton et al., 2012). Furthermore, they assume that areas of UK shelf sediment are uniformly trawled; a consideration highlighted in this report as untrue. However, as explained by Luisetti et al, carbon-rich areas tend to be preferentially trawled due to their higher levels of productivity, whilst repeat-trawling diminishes stored carbon, therefore any disparity in trawling effort across UK shelf sediment is assumed to balance out for the purposes of their study.

With respect to our calculations, we present the amount of carbon stored within shelf sediments inside MPAs as a proportion of the total 205Mt carbon stored in all UK shelf sediments (i.e. inside and outside MPAs) derived by Luisetti et al (2019). Using such coarse calculations does mean the real carbon storage capacity of MPAs will vary. However, in the absence of alternative data, this does provide sufficient insight into the potential for properly managed MPAs to act not only to protect and

[32] i.e. vessels that use demersal towed gear in the absence of pelagic trawl or seine gear. Around 26% of the fleet were excluded due to being registered users of pelagic trawl and/or seine gear in addition to demersal towed gear.
[33] See Luisetti et al (2019) Supplementary material

recover habitats and species, but also to be a tool for storing blue carbon. Similarly, in order to approximate the abatement cost of sediment disturbance we assumed the fishing effort footprint presented by the GFW data is typical of the area that will continue to be fished over the next 25-years in the absence of bans on bottom trawling and dredging. Luisetti et al's 25-year scenario assumes global climate pressures and human activity will continue to increase at current rates. In reality, this itself could affect commercial fish abundance and stock ranges, thereby influencing the fishing footprint (Heath et al., 2012). However, we make it clear that the metrics derived using Luisetti et al (2019) data approximate carbon storage and abatement costs.

Discussion

The three sites with the highest fishing rates were *Central Fladen* ncMPA, an MPA designated to protect burrowed mud habitat in the Scottish offshore area in the northern North Sea[34], *Margate and Long Sands* SAC, designated for sandbanks off the Kent coast[35], and *Haisborough, Hammond and Winterton* SAC, designated to protect reefs and sandbanks off Norfolk's coast[36]. Our analysis has found that, over the four-year period studied, between 95-100% of the area of these sites have experienced some level of demersal fishing. This, together with the fact MPA boundaries closely follow the spatial extent of the habitat they surround means that it is very likely that the demersal gear has come into contact with the vulnerable habitats the sites were originally designated to protect. The first pass of a demersal trawl or dredge is the most destructive for many habitats such as bivalve reefs (Cook et al., 2013; Kaiser, 2006), and fishermen in the 1970s to 1990s regularly used heavier gear to 'prepare the ground'. Such activity was designated to damage seabed habitats, and used heavier fishing gear than successive trawls. Estimates of the impact of bottom trawling in sedimentary UK seabeds has shown a varying response depending on gear and relative coarseness and depth of the habitat, but clearly illustrates that trawl impact has its greatest effect in areas least trawled (Rijnsdorp et al., 2020). These tend to be in areas that provide lesser Catch per Unit Effort (CPUE). As many offshore MPAs have, in many instances (e.g. many MCZs), been designated in areas of relatively minor interest to UK fishers, trawls & dredges should be restricted in order to allow for recovery of seabed richness and productivity. For some sites there is a short-term trade-off, because a good proportion of these sites' surface area occupies regions where demersal fishing has taken place for over a century (e.g. Dogger Bank). Permitting vessels to continue to trawl and dredge the seabed within these MPAs following designation means the sandbanks and reefs they are designed to protect are not given the time nor the space to recover in themselves, and the biodiversity they can support. Instead, vulnerable benthic habitats and associated species around the UK are being maintained in a depleted and rare state, with seabed ecosystems unable to develop, grow and attract greater diversity. Assessing effects of bottom trawling using individual species counts based on current surveillance is inadequate for informing 'Conservation Objectives' for sites. Communities of different associated species, and the complex mosaic habitats they can form are rarely effectively monitored when assessing the relative effects of trawl fishing over time (Benoiist et al., 2019). And 'shifting baselines' mean that MPAs are not representative of the typical species that can colonise natural seabeds and associated mobile species that live in and around this seabed life. Yet, natural mosaics of species and habitats, and how they interplay are vital to understanding ecosystem impacts of fishing.

[34] http://data.jncc.gov.uk/data/8a2f5751-3622-44fd-aa27-407c28984872/CentralFladen-1-SiteSummaryDocument-July14.pdf
[35] https://jncc.gov.uk/jncc-assets/SAC-N2K/UK0030371.pdf
[36] https://jncc.gov.uk/jncc-assets/SAC-N2K/UK0030369.pdf

The fleet composition of the fishing effort recorded within the boundaries of these sites reflects their geographical location, with *Central Fladen* ncMPA experiencing demersal fishing activity from the UK and Danish fleets, *Margate and Long Sands* from the Belgian fleet, and *Haisborough, Hammond and Winterton* from the Dutch fleet. However, when we extend our attention to the remaining seven sites with the highest fishing rates, it becomes apparent that many have experienced greater fishing effort from non-UK vessels; with nearly 60% of the fishing effort recorded inside MPA boundaries having been conducted by vessels registered outside the UK.

These findings raise serious questions regarding the efficacy of the "protection" offered to England's offshore waters by the most recent tranche of MCZs designated in 2019. Our research has found that the areas now covered by these MCZs have all experienced some level of demersal fishing between 2015 and 2018, with half of them experiencing fishing rates exceeding that of *Central Fladen ncMPA*. As our analysis only assessed data up until 2018 we are not able to quantify fishing effort since these 20 sites were designated. However, there are no active fishing restrictions enforced within these MCZs. Consequently, at present, there is nothing stopping this level of demersal fishing activity from continuing, and therefore nothing protecting the subtidal sediment habitats, and associated species these sites have been designated for.

Permitting demersal fishing to continue in all offshore MPAs will also cost the UK an important blue carbon storage resource. Over the past 140 years, bottom trawling gears have significantly jeopardised our seas' capacity to limit climate change through habitat loss, and that without controlling such activity, the marine environment's ability to both fix and store carbon will continue to be compromised. As we show in this study, 13% of the UK's shelf sediment falls within offshore benthic MPAs with *Dogger Bank SAC* having the capacity to store the equivalent amount of carbon to that released by 31,000 return trips from London to Sydney[37]. If continued to be disturbed, the release of carbon emissions from these offshore sites alone will cost the UK economy nearly £1bn to mitigate over the coming 25 years. We must remember, this also means that 87% of shelf sediment habitats fall *outside* offshore benthic MPA boundaries where they are subject to similar fishing pressures. The removal of demersal fishing from MPAs to protect blue carbon as well as biodiversity would therefore create pockets of carbon storage, equipping the UK with an invaluable tool for helping tackle the climate emergency.

To date, we have used an EU-wide consultation and evidence-gathering process to get member states, including the UK, to agree to management measures for our offshore Marine Protected Areas. Despite many NGOs, including the Marine Conservation Society, having challenged this for more than a decade, there is little management of fishing in these sites. From 2021, UK Governments will have powers to fully manage bottom trawling in all offshore MPAs. We have a legal and societal responsibility to safeguard our seas, with Marine Protected Areas making a crucial contribution. Our offshore MPAs for seabed species and habitats should therefore be off-limits to bottom trawling. It is crucial that management of offshore MPAs takes a 'whole-site' approach (where we believe the management of MPAs should be implemented for the entire site where mosaics of habitats are mutually beneficial for biodiversity, life-history stages of constituent species and essential fish habitat (Rees et al., 2020)), with sites maintained with zero trawl & dredge fishing effort to allow vulnerable habitats to recover and thrive over decades. In addition, effective monitoring and enforcement (including the use of comprehensive fishing restrictions) should be achieved through the required use of remote electronic monitoring on-board fishing vessels.

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[37] London to Sydney round-trip (1 passenger travelling economy) = 6 tonnes CO2 (https://co2.myclimate.org/en/offset_further_emissions)

Conclusion

UK seas are amongst the most historically heavily trawled seas on the planet (Halpern et al., 2008). MPAs need to be seen as the best chance to recover our seas to a richer ecological state, rather than to protect them in their current state. The use of 'ecosystem-based management' of the marine environment has been discussed throughout the UK and the EU for decades with very few examples of actually applying the most fundamental measures necessary to recover and restore parts of the ecosystem.

In line with IUCN advice, bottom-towed fishing gears should be excluded from Marine Protected Areas designated for seabed protection as the most basic measure, in the UK and globally. This is to allow us to start managing the seas as an ecosystem. We have designated approximately 318,248 km^2 (36%) of the UK's seas as MPAs, but, in English waters, only 2% of the seabed is actually protected from bottom trawls, in many cases where the nature of the seabed precludes bottom trawl fishing. We believe the Westminster Government promotes a message of active conservation for our seas through its commitment to a MPA 'Blue Belt'. Whilst there has been some small progress inshore, this has been too slow and not gone far enough.

We need MPAs to recover our marine habitats and species, restore important and significant carbon sinks, and protect and recover essential fish habitats, to make fishing truly sustainable and profitable. Effective management of our MPAs is essential for society now and for generations to come.

Recommendations

The UK urgently needs effectively managed Marine Protected Areas to help recover our marine species and habitats, support sustainable fishing and combat climate change.

Now is the time to begin a just transition towards a complete ban on bottom trawling, seining and dredging in offshore Marine Protected Areas designated to protect seabed species and habitats. This transition can only happen by working with local communities and all who benefit from marine resources. The Fisheries Act 2020 provides the opportunity for the UK Government (for England) and the Scottish, Welsh and Northern Irish Governments to manage fisheries in offshore protected areas in their respective jurisdictions.

The commitment to a 'whole-site approach' to managing MPAs within the Department for Environment, Food and Rural Affairs' 25-year plan for English waters, when applied to all sites where mosaics of habitats are mutually beneficial for biodiversity, life-history stages of constituent species and essential fish habitat, provides the potential for the Marine Management Organisation to close offshore seabed designation Marine Protected Areas to bottom trawling, allowing for the recovery, restoration and reparation of entire ecosystems.

The data in this report shows that the government must now ensure that it takes into account the carbon released by human activities – in particular in this case by bottom towed fishing gears – as well as the carbon stored in the marine environment in its carbon accounting. This is imperative moving forwards, particularly considering 93% of the carbon stored in the continental seas of the UK is held in shelf sediments. Investment is needed to establish a good understanding of sediment to blue carbon pathways. Protecting the seabed from bottom towed fishing gear for carbon as well as biodiversity will allow biomass to accumulate thus enriching the UK's blue carbon stores.

In Wales, we are awaiting the designation of offshore Marine Conservation Zones for important seabed species and habitats. Following designation, the Welsh Government should introduce strict management measures within these sites that will prevent damage to the seabed and associated species.

In Scotland, proposed fisheries management measures for offshore MPAs have stalled in the Common Fisheries Policy process. These should be updated by the Scottish Government in response to the intertwined climate and nature crises to deliver a whole-site approach to seabed protection. An independent commission should also be established to recommend transformation of Scotland's Marine Protected Area network and help ensure at least a third of Scotland's seas are highly or fully protected by 2030.

What is key, is that additional regulatory measures be introduced urgently across all UK countries. Introducing new conditions on the general fishing license would be a quick and efficient way of doing this. The MMO's preferred approach of introducing byelaws is currently much more time-consuming. If it is used, it must be speeded up. In either case, remote electronic (real-time) monitoring with cameras on vessels will also be key to help monitor catches and support compliance with management measures.

To date, agreeing fisheries management measures for Marine Protected Areas through a complex Common Fisheries Policy process has been complicated by changing constitutional dynamics between the EU and UK.

Now, with the powers provided by The Fisheries Act 2020, the UK Governments can act more independently to recover our seas and combat climate change.

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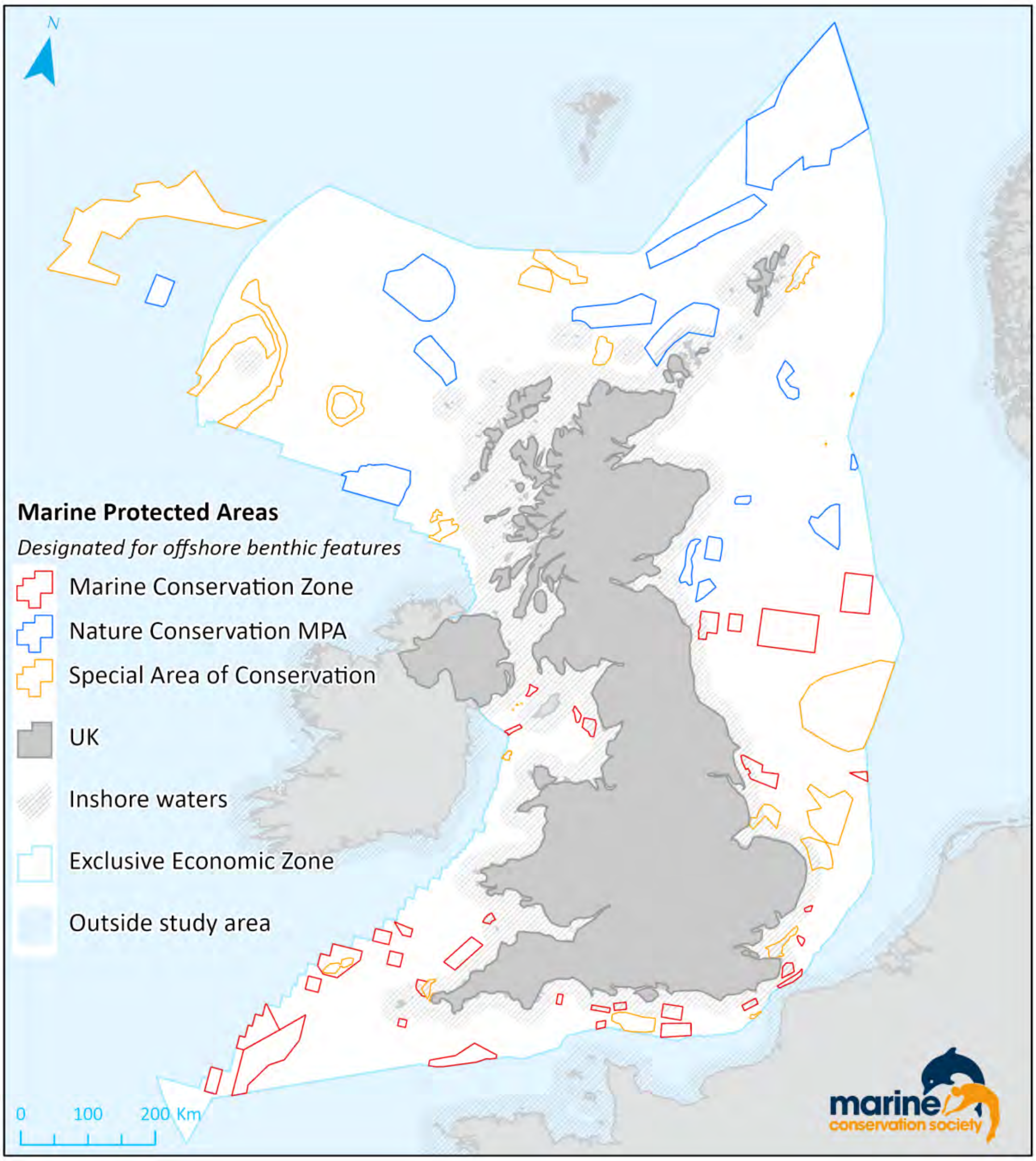
Appendix

Additional data, charts and maps. For additional information, see MPA Reality Check (map.mpa-reality-check.org).

Marine Protected Areas designated for seabed features in the UK's offshore waters (>12nm) defined by site type.



Gears included in the analysis

	Code	Name
Demersal trawls and dredges	DRB	Towed dredges
	DRH	Hand dredges
	HMD	Mechanized dredge
	OTB	Single boat bottom otter trawls
	OTT	Twin bottom otter trawls
	PTB	Bottom pair trawls
	TBB	Beam trawls
	TBN	Nephrops Trawl
Demersal seines	SB	Beach seines
	SDN	Danish seine
	SPR	Pair Seine
	SSC	Scottish Seine
	SV	Boat seines

	Number of vessels			
Gear vessels registered with:	**2015**	**2016**	**2017**	**2018**
Demersal towed gear alone (included in analysis)	10,242	9,920	9,776	9,631
Demersal and pelagic towed gear (excluded from analysis)	3,255	3,364	3,466	3,610
Total	13,497	13,284	13,242	13,241

Blue Carbon metric analysis

Storage and cost metrics from Luisetti et al (2019), EUNIS A5 habitat data from UKSeaMap (2018).

Carbon stored

	Area (km2)	Proportion of total shelf sed	C stored (Mt)
Total UK shelf sediment (A5 habitat)	495,334.80	-	205.00
UK shelf sediment inside MPAs	64,102.93	12.94%	26.53
e.g. Dogger Bank - shelf sediment	12,336.84	2.49%	5.11

Carbon disturbance cost

	Area (km2)	Proportion of total shelf sediment	C disturbance cost (US$million)	C disturbance cost (£million)
Total UK shelf sediment area (A5 habitat)	495,334.80	-	$12,000,000.00	£9,120,000.00
Fished extent of sediment inside MPAs	53,209.76	10.74%	$1,289,061.73	£979,686.91
e.g. Dogger Bank - fished extent of sediment	10,550.99	2.13%	$255,608.69	£194,262.61

Total fishing hours within the offshore UK Marine Protected Areas included in this analysis defined by site type and country. Total fishing hours have not been presented for sites that were designated after the period for which effort data were available.

Country	Code	Name	Type	Designated	Total hours fished
England	UK0030369	Haisborough, Hammond and Winterton	SAC	2010	8832.44
	UK0030358	North Norfolk Sandbanks and Saturn Reef	SAC	2010	7739.67
	UKMCZ0050	Western Channel	MCZ	2016	6461.96
	UKMCZ0047	Greater Haig Fras	MCZ	2016	4486.70
	UKMCZ0049	Offshore Brighton	MCZ	2016	4443.57
	UKMCZ0025	South-West Deeps (West)	MCZ	2013	4340.03
	UK0030371	Margate and Long Sands	SAC	2010	4054.82
	UKMCZ0044	Offshore Overfalls	MCZ	2016	3026.69
	UK0030352	Dogger Bank	SAC	2011	2623.35
	UKMCZ0048	North-West of Jones Bank	MCZ	2016	2218.39
	UKMCZ0023	East of Haig Fras	MCZ	2013	2086.16
	UK0030375	Lands End and Cape Bank	SAC	2010	1536.93
	UKMCZ0027	The Canyons	MCZ	2013	1086.96
	UKMCZ0045	West of Walney	MCZ	2016	1021.19
	UKMCZ0046	Fulmar	MCZ	2016	889.37
	UKMCZ0043	Farnes East	MCZ	2016	762.15
	UK0030353	Haig Fras	SAC	2008	484.80
	UK0030380	Wight-Barfleur Reef	SAC	2012	165.88
	UKMCZ0026	Swallow Sand	MCZ	2013	149.92
	UKMCZ0024	North East of Farnes Deep	MCZ	2013	78.94
	UK0030370	Inner Dowsing, Race Bank and North Ridge	SAC	2010	31.74
	UKMCZ0022	South Dorset	MCZ	2013	7.85
	UKMCZ0051	Albert Field	MCZ	2019	*na*
	UKMCZ0060	Foreland	MCZ	2019	*na*
	UKMCZ0061	Goodwin Sands	MCZ	2019	*na*
	UKMCZ0064	North West of Lundy	MCZ	2019	*na*
	UKMCZ0076	Cape Bank	MCZ	2019	*na*
	UKMCZ0077	East of Start Point	MCZ	2019	*na*
	UKMCZ0078	Holderness Offshore	MCZ	2019	*na*
	UKMCZ0079	Inner Bank	MCZ	2019	*na*
	UKMCZ0082	South of the Isles of Scilly	MCZ	2019	*na*
	UKMCZ0083	South-West Approaches to Bristol Channel	MCZ	2019	*na*
	UKMCZ0084	Markham's Triangle	MCZ	2019	*na*
	UKMCZ0085	North-East of Haig Fras	MCZ	2019	*na*
	UKMCZ0086	Queenie Corner	MCZ	2019	*na*
	UKMCZ0087	South of Celtic Deep	MCZ	2019	*na*
	UKMCZ0088	South Rigg	MCZ	2019	*na*
	UKMCZ0089	South-West Deeps (East)	MCZ	2019	*na*

	UKMCZ0090	West of Copeland	MCZ	2019	*na*
	UKMCZ0091	West of Wight-Barfleur	MCZ	2019	*na*
Wales	UK0030381	Croker Carbonate Slabs	SAC	2012	14.09
Scotland	555560480	Central Fladen	ncMPA	2014	8212.75
	555560478	Firth of Forth Banks Complex	ncMPA	2014	5752.35
	555560479	North-west Orkney	ncMPA	2014	5207.09
	555560481	East of Gannet and Montrose Fields	ncMPA	2014	2626.82
	555560482	Faroe-Shetland Sponge Belt	ncMPA	2014	2184.02
	UK0030385	Pobie Bank Reef	SAC	2012	2071.15
	555560488	The Barra Fan and Hebrides Terrace Seamount	ncMPA	2014	2013.87
	555560483	Geikie Slide and Hebridean Slope	ncMPA	2014	1911.35
	UK0030388	Hatton Bank	SAC	2012	1502.64
	555560490	West Shetland Shelf	ncMPA	2014	670.04
	UK0030359	Stanton Banks	SAC	2008	377.66
	UK0030317	Darwin Mounds	SAC	2008	324.32
	UK0030355	Wyville Thomson Ridge	SAC	2010	250.34
	555560486	Norwegian Boundary Sediment Plain	ncMPA	2014	87.85
	UK0030389	East Rockall Bank	SAC	2012	59.18
	UK0030363	North West Rockall Bank	SAC	2010	22.82
	UK0030386	Solan Bank Reef	SAC	2012	22.64
	555560489	Turbot Bank	ncMPA	2014	21.60
	555560487	Rosemary Bank Seamount	ncMPA	2014	16.19
	555560485	North-east Faroe-Shetland Channel	ncMPA	2014	15.54
	555560484	Hatton-Rockall Basin	ncMPA	2014	0.03
	UK0030387	Anton Dohrn Seamount	SAC	2012	0.00

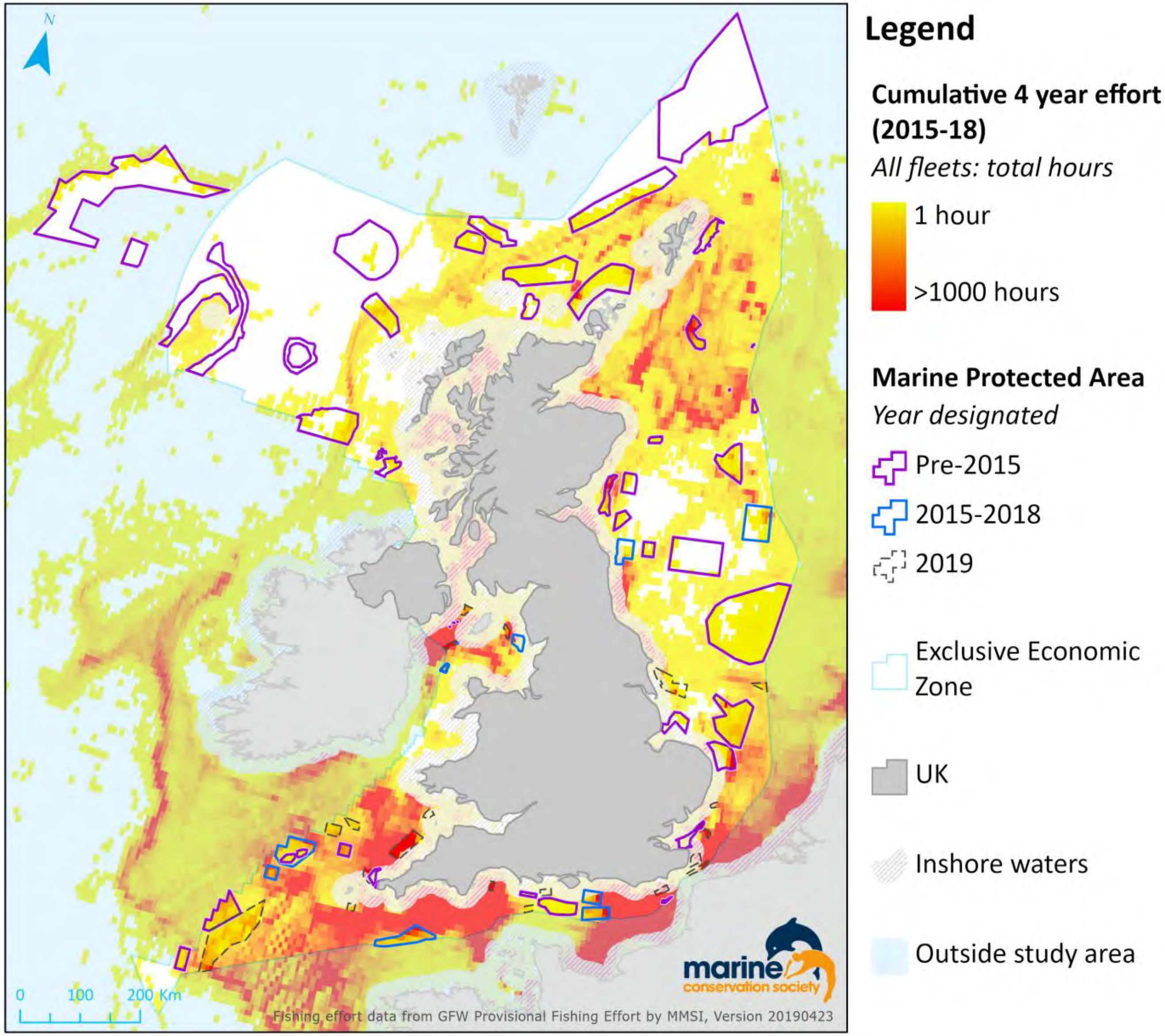


Figure 1 Total cumulative fishing hours inside and outside UK offshore MPAs for the period 2015-18. Effort data from the Global Fishing Watch's provisional fishing effort by vessel dataset is presented in 0.1°x0.1° resolution.

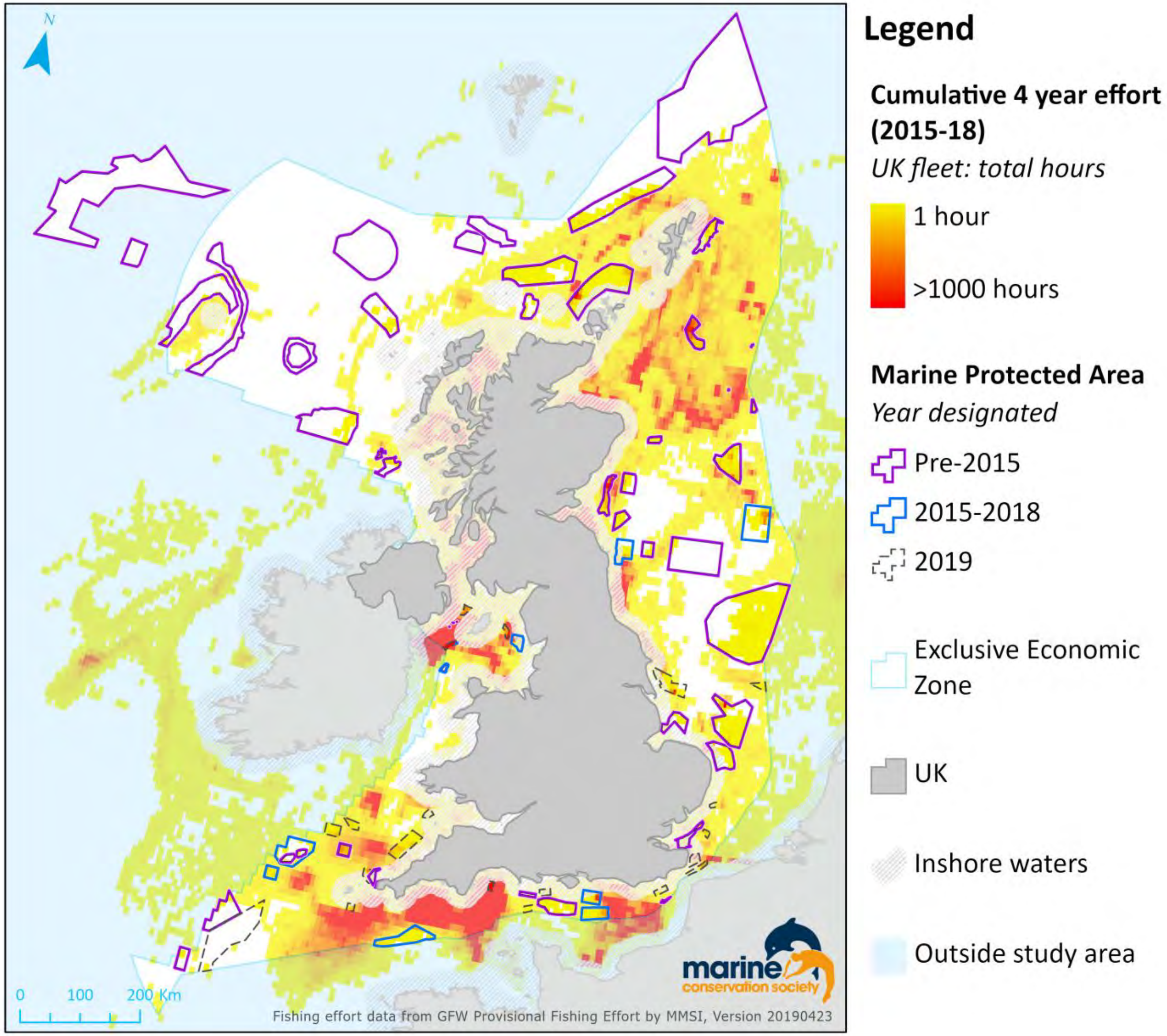


Figure 2 Cumulative fishing effort recorded between 2015 and 2018 defined by the UK fleet

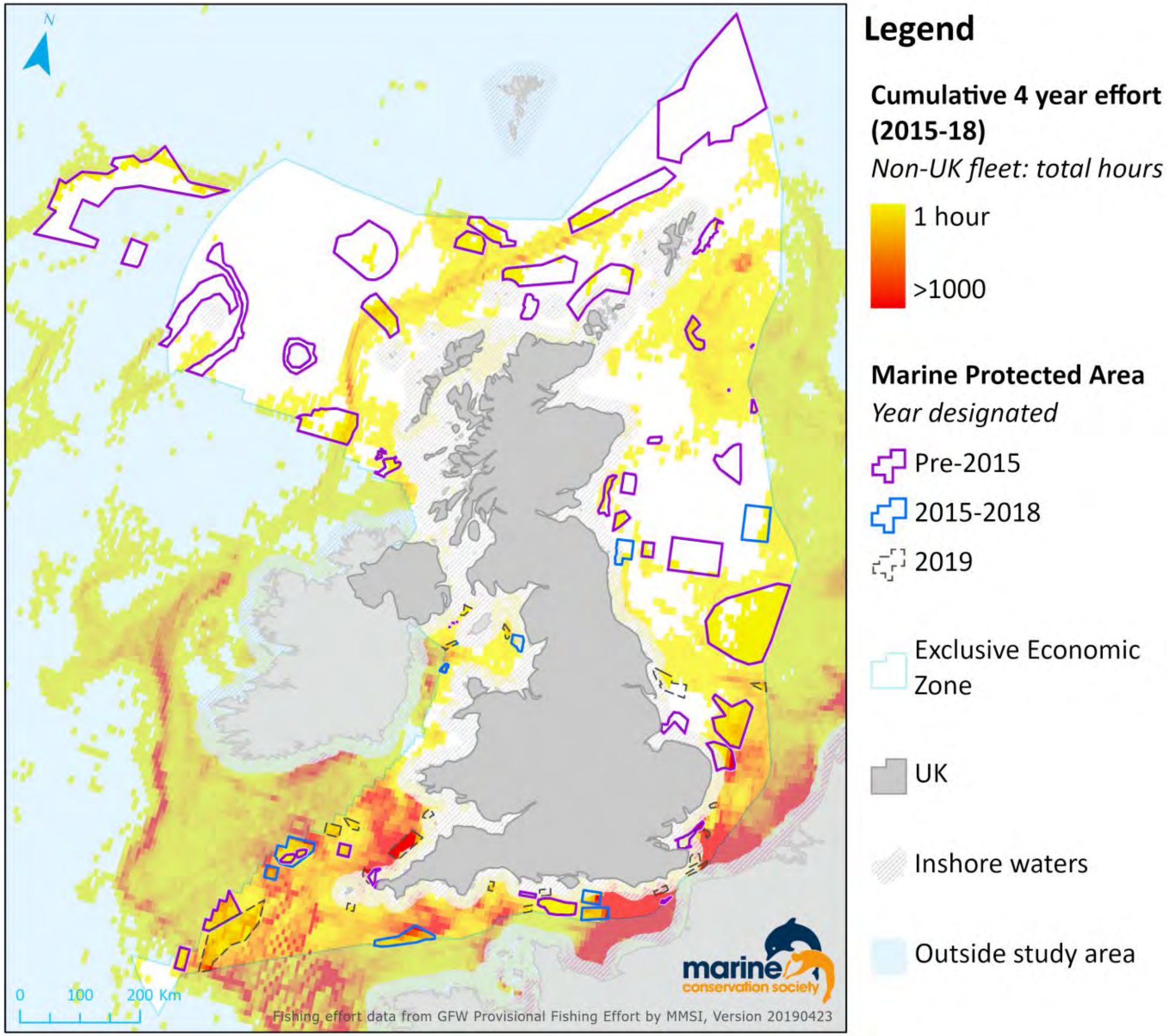


Figure 3 Cumulative fishing effort recorded between 2015 and 2018 defined by other EU fleets.

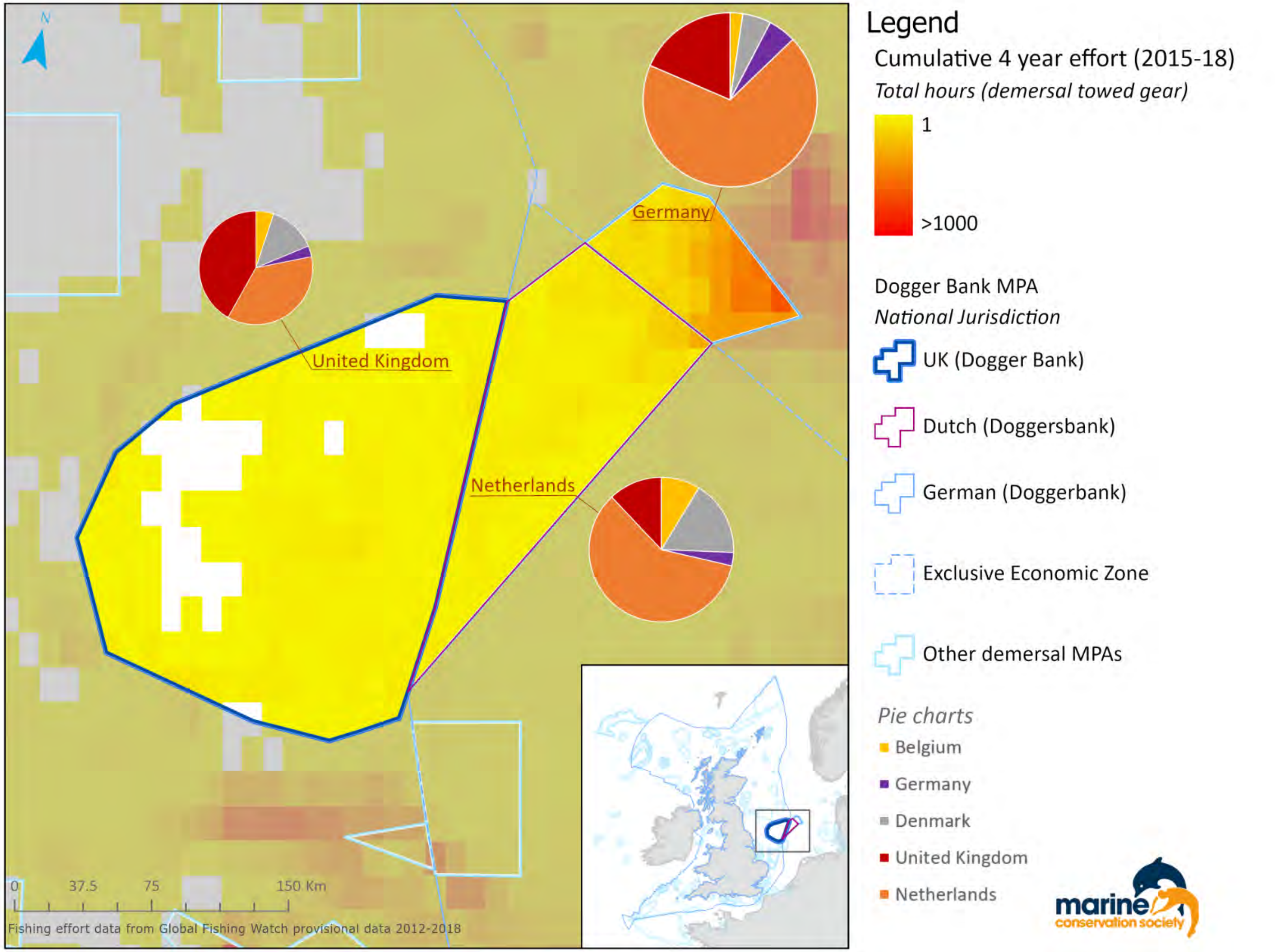
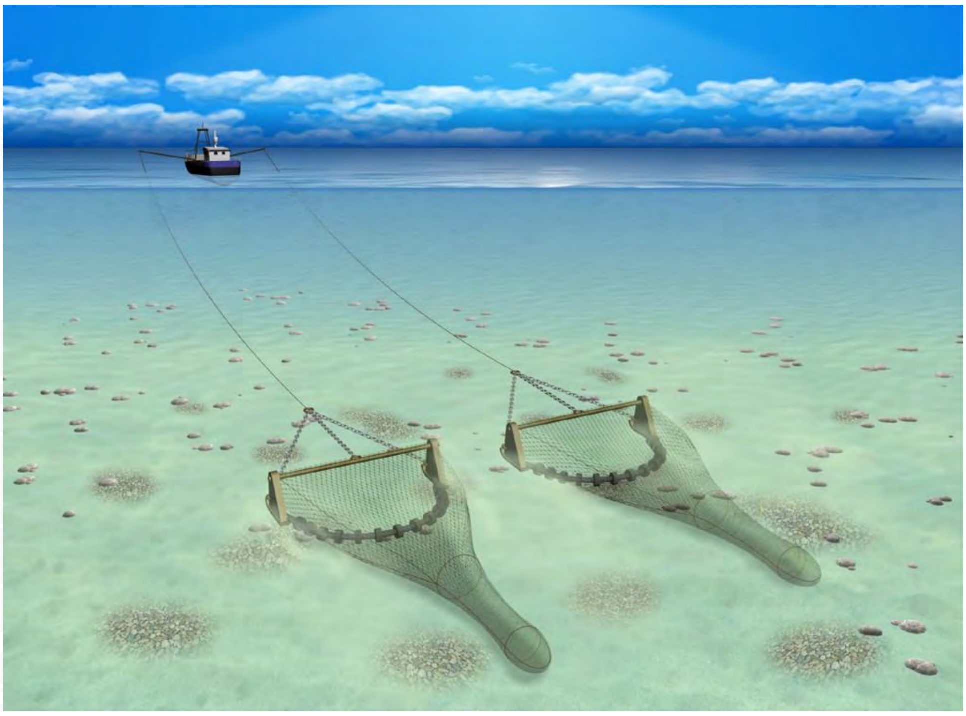


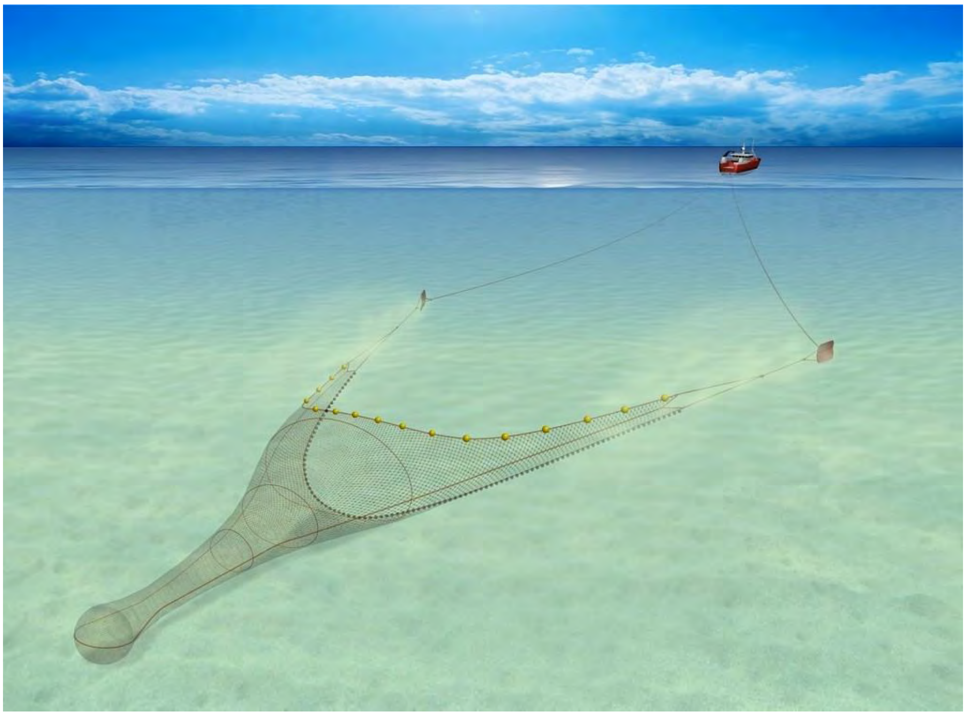
Figure 4 Cumulative fishing effort in the Dogger sandbank MPAs between 2015 and 2018 and a breakdown of cumulative fishing effort fleet composition in the three MPAs sited on the Dogger sandbank. The red shading indicates magnitude of fishing effort. See Appendix for larger map.

Illustrations of some of the gears used (source: Seafish)

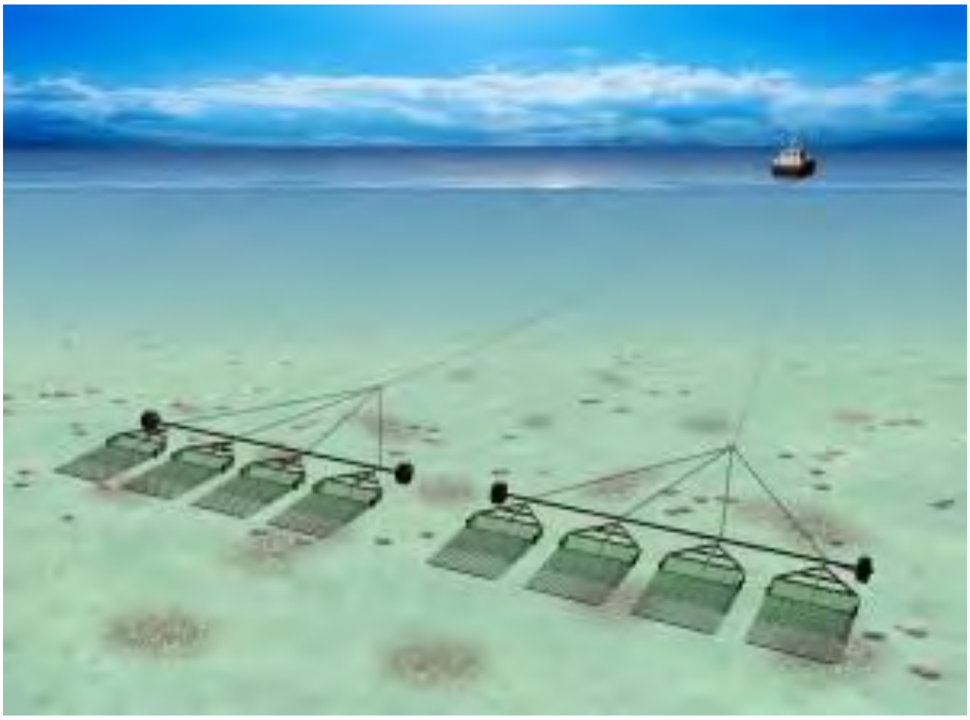
Beam trawl



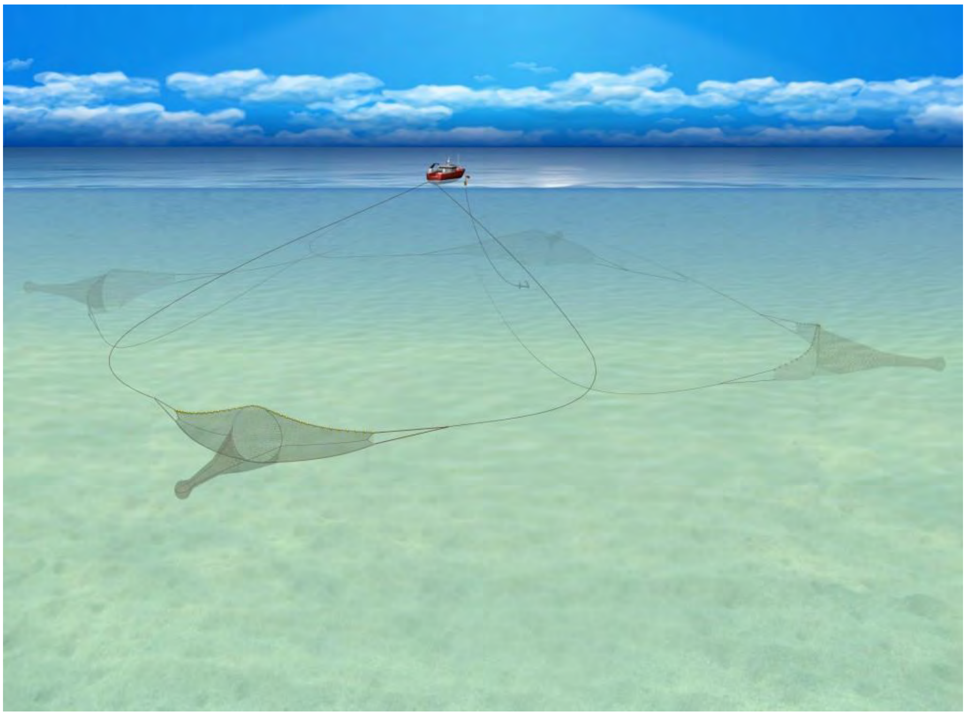
Otter trawl



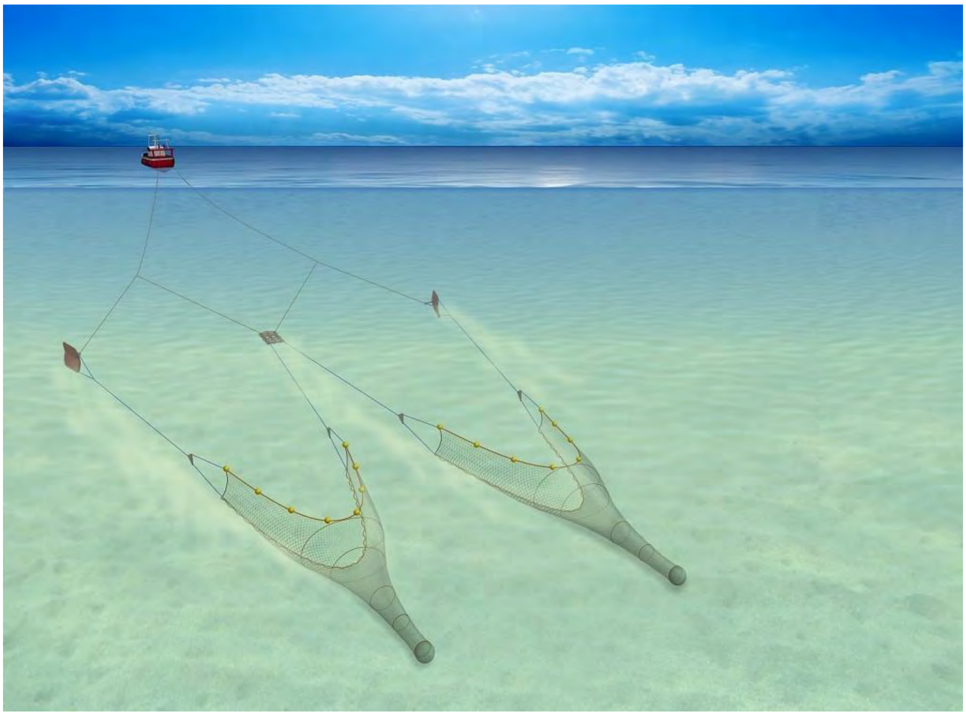
Scallop dredge



Danish seine



Nephrops (twin rig)



The Industry

The UK fishing industry is made up of 4,512 registered active vessels (Seafish, 2018), 74% of which are under 10m. About 1,170 vessels are active and over 10m in size. Seafish calculated for 2018 that there were approximately 1,730 inactive vessels. This is a relatively small industry, with an operating profit of £268 million. 64% of vessels were classed as static fishing – i.e. most fishing is inshore, using low-impact set netting, pots and traps.