Marine Spatial Planning Addressing Climate Effects (MSPACE)

Report of Task 1.3
Seabed Habitat Condition Assessment in the UK EEZ

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Introduction

Evaluating the impact of marine resource extraction and sea floor disturbance on seafloor ecosystem function of UK shelf areas is vital to sustainably meet increasing needs for UK marine resource extraction, whilst meeting ambitions for reaching net-zero (UK Gov, 2019; UNFCCC, 2015) and Good Environmental Status.

The principal benthic impacts evaluated here are from wild capture fisheries, using mobile bottom-contacting gear (MBCG) and from marine aggregate extraction. Scientific research underpinning wild capture fisheries management has primarily fallen into two broad categories: assessing the stock status of commercial and sensitive species (FAO, 2020); and the environmental impact of different fishing gear types on target species, non-target species, and habitat structures (Hiddink et al., 2020; Sciberras et al., 2016; Sciberras & Hiddink, 2014). The magnitude of damage to a habitat is influenced by, but not limited to, attributes such as the type of fishing gear used (and associated penetration depth) (Eigaard et al., 2016a; Hiddink et al., 2017); the history of fishing pressure in a given area or habitat type (Sciberras et al., 2018; Rijnsdorp et al., 2020); the life history characteristics of the biota which make up the habitat (habitat sensitivity) (Hiddink et al., 2019); and the level of natural disturbance (van Denderen et al., 2015). Chronic physical disturbance can lead to topographic and biogeochemical changes (Hale et al., 2017; Sciberras et al., 2016, 2017) which under a scenario of elevated global warming, will be exacerbated and could irreparably alter the ecology of the ocean (Burrows et al., 2021; Moller et al., 2022; Nellemann et al., 2009). Therefore, it is vital to the climate change agenda (e.g. Net Zero strategy) that we are able to predict changes in ecosystem health, under different levels of warming and resource extraction (Pereira et al., 2022).

Pressures from aggregate extraction activities that cause physical disturbance to the seabed can have adverse effects on benthic organisms and habitats (Newell *et al*., 1998; Desprez, 2000; Newell and Woodcock, 2013). The most common method of commercial aggregate extraction in the offshore marine environment is trailer hopper suction dredging, which can create shallow furrows that extend for several kilometres, are initially 0.5 m deep, and are generally 2-3 m wide (Tillin *et al.,* 2011; Last *et al.,* 2011; Newell & Woodcock, 2013). Physical impacts from trailer dredging can extend for several kilometres, and can reduce surface relief by several metres through consistent and repeated dredging within a given location over the duration of a license period (e.g., typically 15 years) (Tillin *et al*., 2011; BMAPA & TCE, 2017). Although less common, static suction dredging, or 'anchor dredging', can create deep (5-10 m) depressions in the seabed, and can be used to target specific types of sediment in localised areas (Tillin *et al.,* 2011; Last *et al.,* 2011; Newell & Woodcock, 2013). Dredging depressions can create geological irregularities in the seabed, with infill and degradation rates varying dependent on local and regional hydrodynamic and sedimentation regimes (BMAPA & TCE, 2017). Monitoring suggests that trailer dredge furrows can degrade over durations of 3 to 7 years following impact (Cooper *et al*., 2005). In contrast, deeper, more prominent depressions, often associated with static dredging can degrade over longer timeframes, sometimes resulting in a permanent lowering of the seabed (Cooper *et al*., 2007).

Task 1.3 of the SMMR project aims to deliver an assessment for the effect of mobile bottom contacting gear (MBCG) and marine aggregate extraction on soft sediment and OSPAR threatened and/or declining habitats across the UK Economic Exclusion Zone (EEZ) using the Relative Benthic Status (RBS) and the Extent of Physical Disturbance to Benthic Habitats (BH3) indicators currently being used by ICES and OSPAR, respectively, for habitat condition assessments (

Table 1).

Table 1. *Indicators used to assess the effects of anthropogenic physical disturbance activities on benthic habitats and fauna. RBS = Relative Benthic Status; BH3a = Extent of Physical Disturbance to Benthic Habitats (fisheries with mobile bottom-contacting gears); BH3b = Extent of Physical Disturbance to Benthic Habitats (aggregate extraction)*

	Bottom Trawling	**Aggregate Extraction**
EUNIS Broad Scale and Mosaics Habitats	BH3a, RBS	BH3b
Threatened and/or Declining Habitats	BH3a	BH3b

The BH3 and RBS methodologies have key differences (**Table 2**) meaning the results are not directly comparible but complimentary, working in tandem to address the overall aim of SMMR Task 1.3. BH3 is a pressure indicator that estimates the level of physical disturbance human activities can cause to benthic habitats. Where known pressure-activity links are established, pressure data are combined with sensitivity information to assess the spatial extent and magnitude of anthropogenic seafloor physical disturbance. The RBS indicator is a condition indicator that uses biomass, species trait and pressure information to evaluate the state of the benthic community following disturbance. The RBS uses depletion and recovery estimates from global meta-analysis to calculate trawling-induced changes in community biomass relative to the carrying capacity of the community without trawling.

Table 2. *A summary of differences between the two methodologies applied under SMMR WP1.3, Relative Benthic Status (RBS) and Benthic Habitats 3 (BH3) indicator.*

Indicator	**RBS**	**BH3**
Aims	Aims to assess the impact of bottom fishing disturbance through changes in community biomass and structure	Aims to assess the spatial extent and magnitude of physical disturbance caused by anthropogenic activity (bottom fishing, marine aggregate extraction)
Applicability to benthic data	Analysis is designed to be applied to benthic macrofaunal species (infauna & epifauna) and sedimentary habitats	Analysis can be applied to all subtidal benthic species and habitat types
Biological data type used	Biomass data	Presence / absence data
Data requirements	Fishing pressure (swept area ratio, F), seafloor habitat map, benthic fauna biomass, species trait data (longevity), depletion (d) and recovery (r) values from global meta-analysis	Fishing/aggregate extraction pressure (swept area ratio), seafloor habitat map, benthic species presence & absence data, species and habitat sensitivity (defined as resilience and resistance)

Impact calculation	Impact is calculated using a mechanistic model based on the logistic population growth model developed by Pitcher et al. 2017, doi:10.1111/2041-210X.12705 $Community\ \ state = \frac{B}{K} = 1 - F\frac{d}{r},$	Impact (aka Disturbance) is calculated at the highest habitat resolution available by spatially intersecting pressure and sensitivity information. A matrix approach, developed from modelled fishery-induced mortality rates ((Schroder et al 2008; BioConsult 2013), is used to combine pressure categories and habitat sensitivity categories and define disturbance.
Spatial coverage	Due to the availability species biomass data and the modelling approach applied, the UK RBS results have a restricted spatial output. Confidence in the pressure information and indicator outputs is currently lower for inshore areas due to the absence of VMS data for vessels below 12 meters length	The availability of less granular species data and methodology mean UK BH3 results are provided for the whole UK EEZ. Confidence in the pressure information and indicator outputs is currently lower for inshore areas due to the absence of VMS data for vessels below 12 meters length; please note, improved data coverage forthcoming in future assessments.
Indicator outputs	Results are presented on a continuous scale of 0-1, where 1 represents an unimpacted benthic community and 0 means none of the original community structure is left	Results are presented as categorical, with categories of disturbance ranging from 0-9, where 9 is the maximum risk of disturbance possible. For reporting purposes disturbance categories are then further aggregated into broader groups (Zero-Low-Moderate-High)

To facilitate the production of complimentary resuts, where there was overlaping data requirements under RBS and BH3, identical data sources were used:

- Both RBS and BH3 use the same habitat map (Castle L, n.d.) to summarise results per habitat type (note, the RBS method reduced the granularity of habitat type distribution by redefining habitat types to a higher EUNIS level (**Annex Table 6**).
- Both RBS and BH3 use the same fishing pressure data layers (ICES, 2021).

Method

Extent of Physical Disturbance to Benthic Habitats (BH3) Indicator

The BH3 indicator assesses the spatial extent and magnitude of physical disturbance to the seafloor that can be caused by human activities. In brief, the BH3 method combines two types of information to produce a map of habitat disturbance: 1) the distribution and sensitivity of habitats and species and

2) the distribution and intensity of human activities and pressures that cause physical damage (e.g., trawling or aggregate extraction) (**Figure 2**).

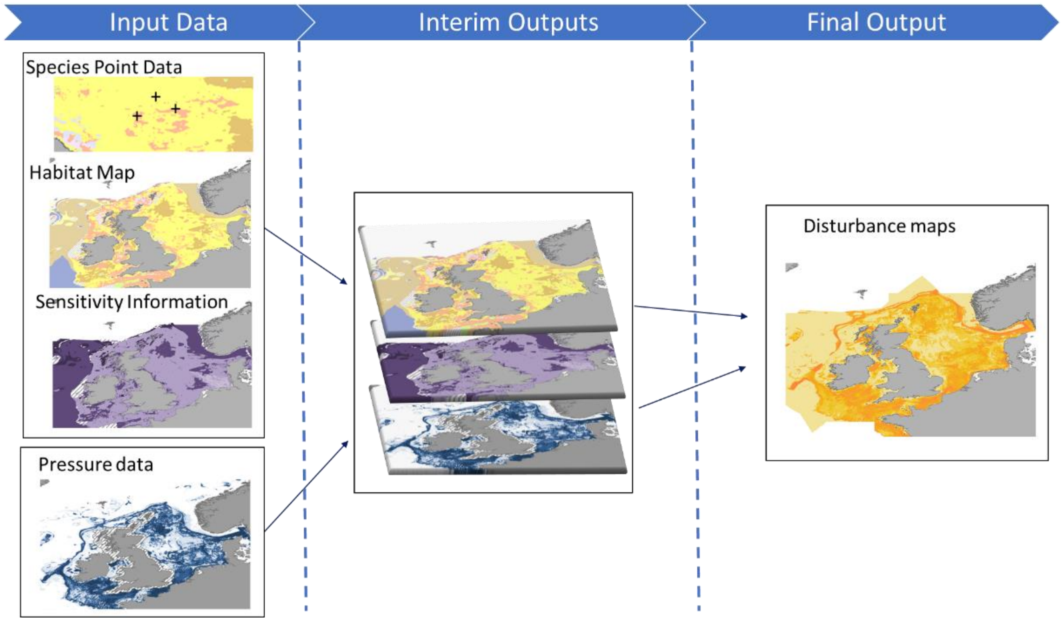

Figure 2. *Interlinkage between data inputs, processes, and outputs for the BH3 indicator*

The BH3 indicator is computed in four steps:

1. **Creation of a composite habitat map** showing the extent and distribution of seafloor habitats at different scales of the EUNIS 2007 classification based on observational and modelled data. It contains all habitat data available at different types of resolution.
2. **Assessment of species and habitat sensitivity**, derived from the data and information available on their resistance (ability to withstand a given pressure) and resilience (ability of a habitat to recover)
3. **Assessment of distribution and intensity of pressures** from human activities causing physical disturbance (surface abrasion, subsurface abrasion, extraction) to the seabed.
4. **Calculation of potential disturbance of benthic habitats** based on the intensity of pressures and degree of habitat sensitivity per pressure type.

Step 1: Creation of a composite habitat map

A composite habitat map was developed to show the extent and distribution of broad-scale seabed habitats. This map was built from both *in-situ* survey datasets and modelled MSFD Benthic Broad Habitat Types or EUNIS habitat data (in the absence of direct sample data). Habitats were mapped to the highest resolution of detail available, ranging from EUNIS Level 2 (physical habitats) to Level 6 (biological communities).
A separate habitat map was used to specifically map the distribution of OSPAR Threatened and / or Declining Habitats (OSPAR, 2008): the OSPAR Habitats in the North-East Atlantic Ocean - 2020 Polygons layer (EMODnet, 2020). The layer is a compilation of OSPAR Threatened and / or Declining Habitats data submitted by OSPAR Contracting Parties on an annual basis and is a separate data product to the composite habitat map will all habitat types.

At UK EEZ scale, the composite habitat map was based on the following data products

- **Habitat maps created from survey data**. These include publicly available survey data from the Natural England Evidence Base (inshore waters up to 12 nm) and from UK offshore survey datasets (beyond 12 nm)
- **UKSeaMap 2018**: this is a broad-scale predictive habitat map created by overlaying classified oceanographic models with a broad-scale substrate map (Manca & Lillis, 2022, in-prep.). The UKSeaMap 2018 is a version of EUSeaMap[1] that incorporated greater spatial resolution data available in United Kingdom waters, as revised by the Joint Nature Conservation Committee (JNCC).

UKSeaMap data were combined with *in-situ* survey datasets through two confidence-scoring mechanisms to ensure the best available data were mapped. Primarily, data were analyzed for MESH (Mapping European Seabed Habitats) confidence, which assessed the quality of the processes used to create the map (e.g., maps derived from remote sensing and ground-truthing to inform habitat classification were prioritised over modelled data) (Castle *et al.,* 2021). Subsequently, maps were reanalysed using a three-step confidence-scoring mechanism to produce a qualitative score, indicative of the likelihood of habitats being mapped correctly within a study area (please see Ellwood, (2014) for full detail of the three-step confidence assessment):

1. Remote sensing coverage
2. Amount of sampling
3. Distinctness of class boundaries

All data included were also quality checked using a five-stage stepwise method to resolve GIS errors and overlapping habitat polygons to ensure that the most accurate polygon was represented in final map outputs. An overview of the five stages is represented below:

1. If one layer contained all intertidal habitats and another layer contained all subtidal habitats, the layer containing all intertidal habitats was used. A prioritisation of layers containing intertidal habitats was undertaken, as intertidal maps were generally produced with better detail and resolution than subtidal data and therefore, had better accuracy. Where both layers contained all intertidal or all subtidal habitats, or either layer contained a mixture of intertidal and subtidal habitats, stage 2 was implemented.
2. The layer with the highest 3-step confidence score was used, where the 3-step confidence score was the same, stage 3 was implemented.
3. The layer derived from survey data was prioritised over modelled data derived from EUSeaMap; where both layers were based on survey data, stage 4 was implemented.
4. The layer with the highest MESH confidence score was used; where both layers shared the same MESH confidence score, stage 5 was implemented.
5. Expert judgement on the most likely layer to indicate EUNIS Level 3 habitat was applied, and that layer was used.

This process was repeated until all overlapping polygons had been resolved within the layer. Once overlapping polygons had been resolved to represent the habitat most likely present in the area, a 'Repair Geometry' tool was used to resolve any geometry errors in the composite habitat map. Please

[1] EUSeaMap is updated every 2-3 years, developed using a suite of EMODnet products, including EMODnet Bathymetry, EMODnet Geology and Copernicus marine services via the Copernicus Marine Environment Monitoring Service (CMEMS) (Vasquez, *et al*., 2021). Additional physical data used for the calculation of the models include data on light attenuation, light at the seabed and kinetic, current and wave energy datasets. For further detail on associated data products, please see EMODnet (2021).

see Castle *et al.* (2021) for further information on the methodology used to create the composite habitat map product.

Step 2: Assessment of species and habitat sensitivity

The second step of the BH3 method is aimed to assign a sensitivity score to seabed habitats and species which reflects their ability to resist and recover from impacts. The final product of this step is a sensitivity map at UK EEZ scale for each pressure type considered.

Collating Species Point Data

The extent and distribution of Habitat polygons produced under 'Step 1' was integrated with sampled *in-situ* species point data collected from during the period 2009-2020. This time period was selected to overlap with the temporal coverage of the biological dataset with available pressure information (see Step 3).

Species points were extracted from the public version of Marine Recorder (version "2022-01-24") supplemented by additional data falling within the UK EEZ that were obtained via an OSPAR data call. For the assessment of aggregate extraction disturbance, additional species points were extracted from OneBenthic faunal database, which contains industry data from locations relevant to those licensed for aggregate extraction (OneBenthic database, 2020).

BH3 is not restricted to a particular type of biological data, as it only requires the identity and distribution of species to define the point data layer. For example, having quantified measures (abundance or biomass) for each species is not required, therefore, all available survey data collated in the above-mentioned time period were used without any filter applied during data extraction. The distribution of survey datapoints underpinning BH3 analyses is shown in **Figure 3**.

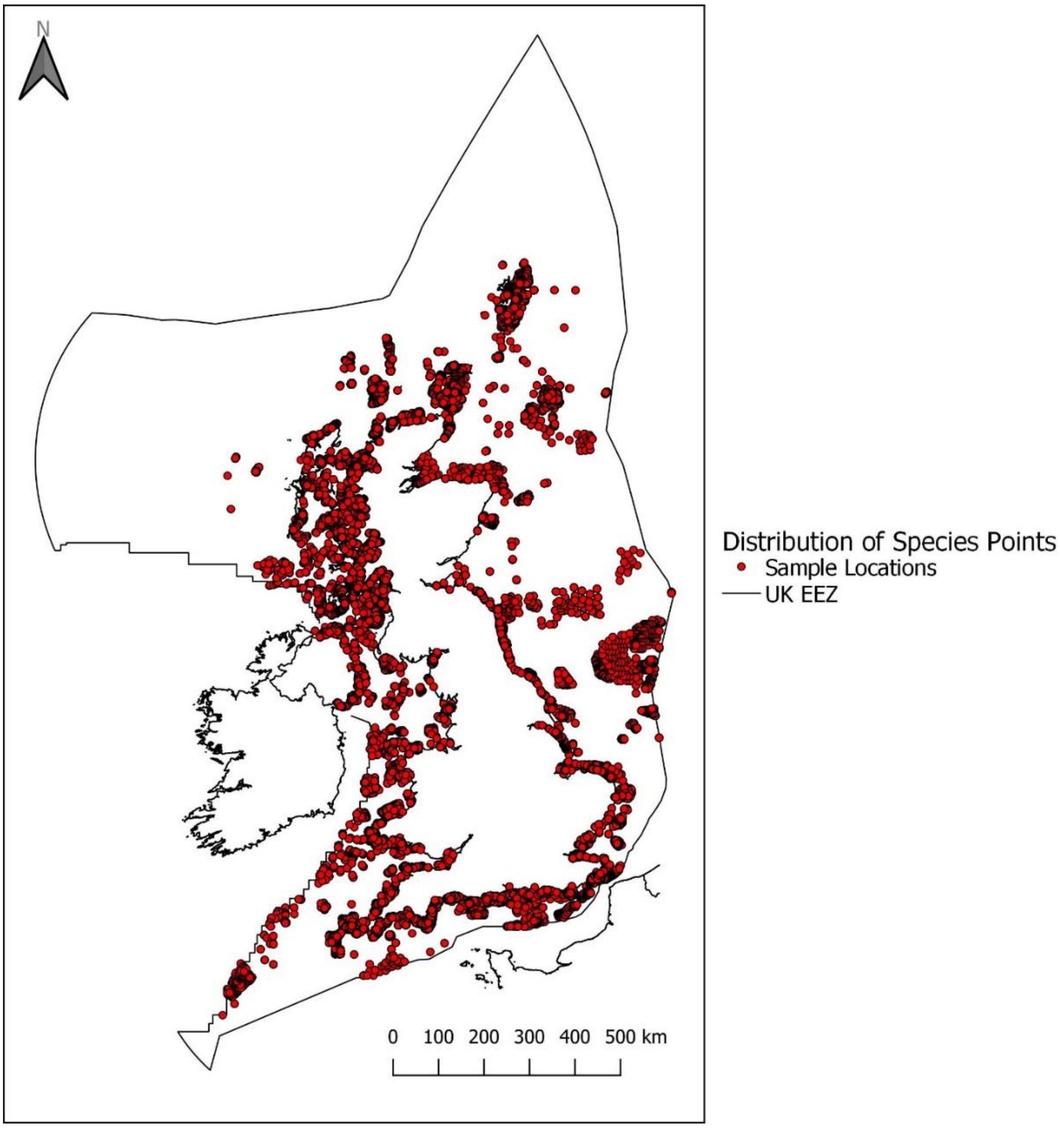

Figure 3. *Distribution of species point data used by BH3 at the UK EEZ scale.*

Assigning sensitivity information

Once updated information on distribution of seabed habitat and benthic species was obtained, information on their sensitivity to physical damage caused by trawling and aggregate extraction was sourced.

The following pressures were considered for assessments of bottom-contact fishing:

- Abrasion/disturbance at the surface of the substratum
- Penetration and/or disturbance of the substratum below the surface

The following pressure was considered for assessments of aggregate extraction:

- Habitat structure changes - removal of substratum (extraction)[2]

[2] This pressure refers to temporary change: Unlike the "physical change" pressure type where there is a permanent change in sea bed type (e.g. sand to gravel, sediment to a hard artificial substrate) the "habitat structure change" pressure type relates to temporary and/or reversible change, e.g. from marine mineral extraction where a proportion of seabed sands or gravels are removed but a residual layer of seabed is similar

Sensitivity information to these three pressures were extracted from two sources:

1. **Marine Evidence based Sensitivity Assessments (MarESA).** MarESA is a scientific approach to assessing habitat sensitivity (including habitat characterising species) to a range of pressures, based on those defined by the OSPAR Intercessional Correspondence Group on Cumulative Effects (ICG-C) (OSPAR, 2011 & 2014; Tyler-Walters et al., 2018). Evidence used to inform MarESA assessments were representative of organisms and biotopes, including their known ranges and distributions, in response to specific pressures. Evidence was prioritised based on its relevance to assessed features; for example, evidence from the North-East Atlantic was prioritised over literature and studies from elsewhere when assessing organisms found in the North-East Atlantic. In addition, MarESA sensitivity assessments underwent quality assurance checks by the Marine Life Information Network (MarLIN) Editor and were peer reviewed by one or more independent expert(s) (Tyler-Walters, *et al*., 2018).

2. **Defra MB0102** Report No. 22, Task 3: Development of a Sensitivity Matrix (pressures-MCZ / MPA features) (hereafter referred to as MB0102) (Tillin *et al*., 2010; Tyler-Walters *et al*., 2018). MB0102 was a Defra funded project completed to support the designation of Marine Conservation Zone MPAs under the Marine and Coastal Access Act in the United Kingdom. Outputs of the project included sensitivity assessments for designated MPA features, EUNIS Level 3 broad-scale habitats and OSPAR Threatened and / or Declining Habitats to pressures in the marine environment, alongside associated pressure benchmarks (Tillin et al., 2010). In MB0102, species that characterised sublittoral rock and sediment habitats were assessed for their sensitivity to pressures in groups of taxa with similar biological traits. The resistance and resilience of characteristic species were assessed in response to defined pressures via literature review and expert judgement. Please see Tillin and Walters (2014a), Tillin and Walters (2014b), Maher and Alexander (2016) and Maher et al., (2016) for details of habitat characterising species, trait-based groupings, sensitivity assessments and assessment confidence scores.

When developing BH3 sensitivity layers, MarESA was prioritised over MB0102 sensitivity due to improved data quality and accuracy. MB0102 relied on expert judgement, whereas MarESA assessments were literature-based, peer-reviewed publications from monitoring data that included detailed evaluations of evidence used to inform assessments and audit trails. Therefore, MB0102 sensitivity information was only used in instances where species or habitat records did not have completed MarESA sensitivity assessments.

In both MarESA and MB0102, sensitivity is defined as a combination of receptor **Resistance,** i.e., ability to withstand change following exposure to pressure (

Table 3) and **Resilience**, i.e. time taken and therefore, ability to recover to an unimpacted state (**Table 4**).

Table 3. *Criteria used to assess resistance, adapted from Tyler-Walters et al., (2018).*

Resistance	Description
None	Key functional, structural, characterizing species severely decline and/or physicochemical parameters are also affected e.g. removal of habitats causing a change in habitats type. A severe decline/reduction relates to the loss of 75% of the extent, density or abundance of the selected species or habitat component e.g. loss of 75% substratum (where this can be sensibly applied).

to the pre-dredge structure and as such biological communities could re-colonise; navigation dredging to maintain channels where the silts or sands removed are replaced by non-anthropogenic mechanisms so the sediment typology is not changed (http://vocab.nerc.ac.uk/collection/M14/current/.)

Low	Significant mortality of key and characterizing species with some effects on the physicochemical character of habitat. A significant decline/reduction relates to the loss of 25-75% of the extent, density, or abundance of the selected species or habitat component e.g. loss of 25-75% of the substratum.
Medium	Some mortality of species (can be significant where these are not keystone structural/functional and characterizing species) without change to habitats relates to the loss <25% of the species or habitat component.
High	No significant effects on the physicochemical character of habitat and no effect on population viability of key/characterizing species but may affect feeding, respiration and reproduction rates.

Table 4. *Criteria used to assess resilience, adapted from Tyler-Walters et al., (2018).*

Resilience	Description
Very Low	Negligible or prolonged recovery possible; at least 25 years to recover structure and function
Low	Full recovery within 10-25 years
Medium	Full recovery within 2-10 years
High	Full recovery within 2 years

The BH3 indicator combines resistance and resilience information using a sensitivity matrix, to derive a unique sensitivity score specific to each pressure (**Table 5**). The sensitivity scores range from 1 to 5, with 5 being the most sensitive.

Table 5. *Sensitivity matrix combining resistance and resilience scores to produce a sensitivity score ranging from 1 to 5, where 5 is the most sensitive.*

Sensitivity		**Resilience** very low (>25 yr.)	low (>10-25 yr.)	medium (>2-10 yr.)	high (1-2 yr.)	very high (<1 yr.)
Resistance	none	5	4	4	3	2
	low	4	4	3	3	2
	medium	4	3	3	2	1
	high	3	3	2	2	1

<u>Assigning sensitivity to habitats:</u>

MarESA habitat sensitivity assessments were available for a diversity of biotopes, ranging from Level 4 to 6 of the EUNIS classification, complete with detailed evaluations and audit trails of the information used to assess sensitivity (Tyler-Walters, 2018; Last *et al.* 2020). Wherever possible, biotope-scale assessments were used in disturbance calculations (e.g., EUNIS Levels 4, 5 and 6).

Due to data paucity, sensitivity assessments were not available at all resolutions of habitat map polygons; particularly, when mapping at a broadscale-habitat scale (e.g., EUNIS Levels 2 and 3). Therefore, automated methods based on the JNCC MarESA Aggregation were developed in Python 3.6 (Python Software Foundation, 2020), to aggregate biotope-resolution resistance and resilience data to all higher hierarchical tiers of the EUNIS classification (Last *et al.,* 2020). Aggregation of resistance and resilience values across tiers of the EUNIS hierarchy enabled the lowest possible child biotope resistance and resilience values to assessed pressures to be assigned to parent biotopes, following the precautionary principle. Following aggregation, precautionary resistance and resilience values were converted to sensitivity scores using the aforementioned sensitivity matrix (**Table 5**). For further detail on aggregation methods, see Last *et al.,* (2020).

To maximise available data coverage, MB0102 sensitivity assessments were used for habitats that did not have MarESA assessments (i.e., EUNIS A6 'Deep-sea' habitats not assessed, or sensitivity not available for the assessed pressures).

<u>Assigning sensitivity to species:</u>

Species-specific resistance and resilience scores were derived from MarESA. MarESA sensitivity data had higher confidence and accuracy than MB0102 and were therefore, prioritised over MB0102. However, in instances where MarESA sensitivity values were not available for a given habitat, MB012 data were used to bridge data gaps and maximise coverage, increasing the total number of species with associated sensitivity assessments. In instances where multiple MB0102 sensitivity scores were available for the same species or habitat, scores with the highest confidence were assigned, if confidence assessments were equal, then the most precautionary values were used.

Creating a final sensitivity layer

Once habitat and species sensitivity data were assigned to the composite habitat map and the species point data respectively, the sensitivity map used in the BH3 assessment was created using the following stages:

- Stage one: The composite habitat map, with associated habitat sensitivity values added, was spatially intersected in ESRI Arc GIS v10.1 with a 0.05° x 0.05° grid (spatially aligned with ICES c-squares) to create a gridded habitat sensitivity layer. This grid resolution was chosen to align with the resolution of the VMS pressure data. To produce the sensitivity map for commercial aggregate extraction, the composite habitat map was intersected with a 50 m x 50 m grid to align with the resolution of aggregate extraction pressure data.

- Stage two: The *in-situ* species points records were spatially joined to individual habitat polygons within 0.05° x 0.05° grid cells. In instances where multiple species points overlapped a single habitat polygon within a 0.05° x 0.05° grid cell, only the maximum species sensitivity value was joined as a precautionary approach to avoid assigning sensitivity based on less sensitive opportunistic species that may occur in high abundances in areas already been impacted by human activities. This created a polygon layer with both habitat and, where available, species sensitivity values. The same process was used for the aggregate extraction sensitivity assessments, with the difference that a 50 m x 50 m grid was used instead of the 0.05° x 0.05° (to align with the resolution of the pressure data).

- Stage three: Where *in-situ* species sensitivity was present the maximum value between the habitat and species sensitivity was assigned as the final sensitivity value, following the precautionary principle. If species sensitivity was higher, and therefore, prioritised over habitat sensitivity, the species sensitivity value was only assigned to the portion of the polygon within the c-square (or 50m x50m grid in case of aggregates extraction) where the record was observed to maximise representativity.

The final sensitivity layers for fishing pressure (surface and subsurface abrasion) are presented in **Figure 4**. The final sensitivity layer for aggregate extraction pressure is displayed in **Figure 5**, given the limited area of aggregate extraction activities, pie-charts showing proportion of assessed area under different sensitivity levels are also included.

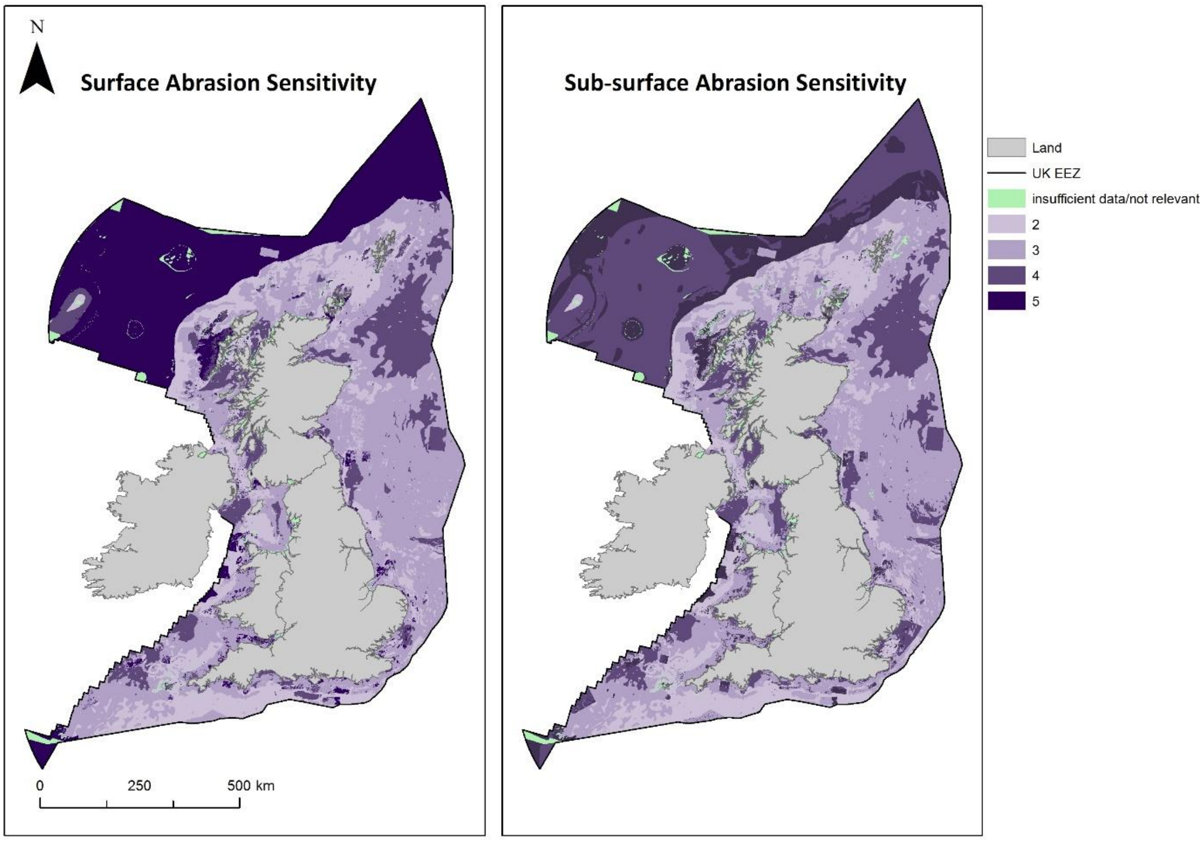

Figure 4. *Extent and distribution of benthic habitat and species sensitivity to fishing pressure sensitivity map. The sensitivity score ranges from 1 to 5, where 5 is the most sensitive.*

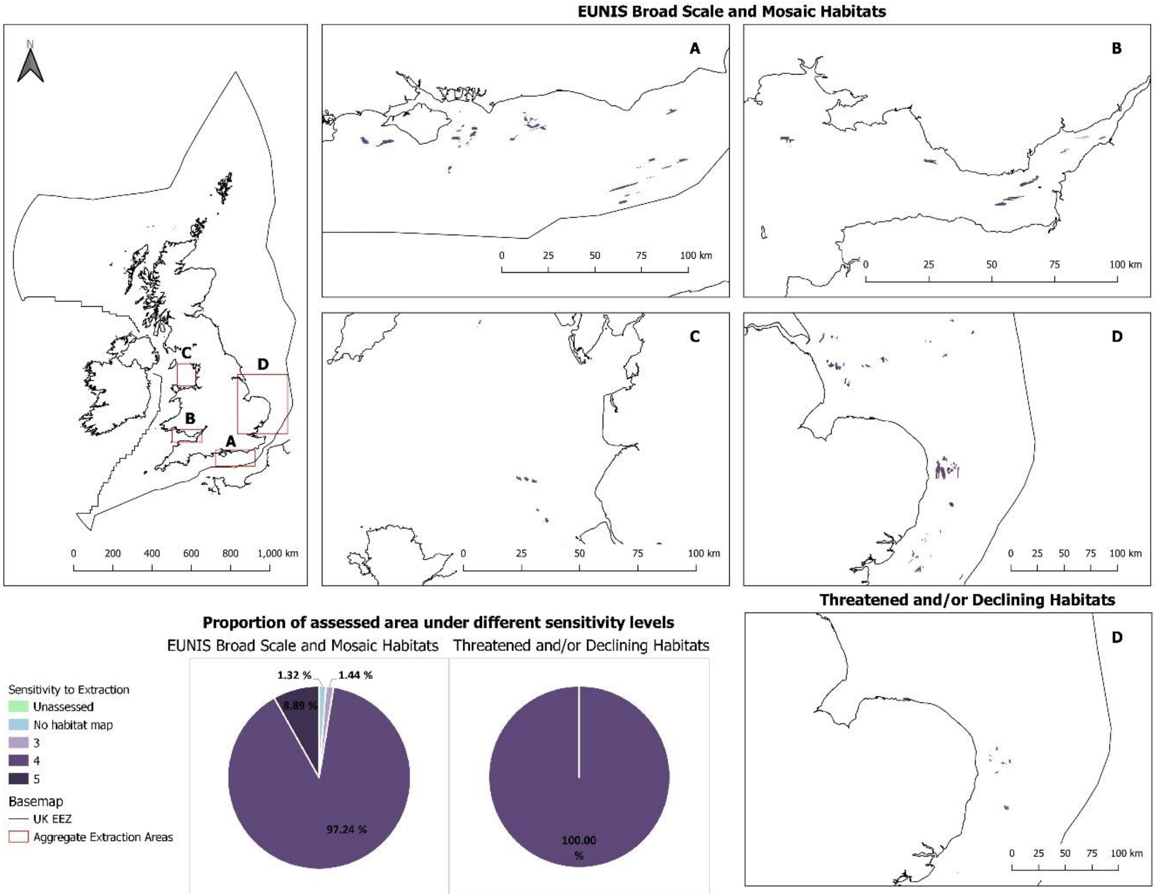

Figure 5. *Extent and distribution of habitat and benthic species sensitivities (based on resilience and resistance) to aggregate extraction combined with EUNIS Level 2-6 benthic habitat types, and Sabellaria spinulosa (Threatened and/or Declining Habitats). The sensitivity score ranges from 1 to 5, where 5 is the most sensitive.*

Step 3: Assessment of distribution and intensity of pressures

Trawling

Annual assessments of bottom-contact fishing pressure were conducted on categorised surface and subsurface SAR values. Categories were based on an intensity scale, ranging from 'none' to 'very high' where a cell has been swept more than 300% or three times per year (**Table 6**). The intensity scale was developed from peer reviewed literature on the impacts of bottom trawling on benthic ecosystems, and the scale was proposed and agreed within the OSPAR Benthic Habitats Expert Group (OSPAR, 2017b).

Surface and subsurface SAR data were categorised separately using the pressure intensity scale outlined in **Table 6** to enable independent assessment of the two separate pressures; both pressures, although spatially linked, were not considered additively, synergistically, or cumulatively. The results of Schroeder *et al.,* (2008) indicated that a SAR of 1 was considered to have a high impact on species abundance. However, SAR values between 0 and 1 were split into three categories based on the results of calculations of van Loon (2018), suggesting a significant biological response between SAR values of 0.15 to 1. Furthermore, areas that were fished more than three times per year did not show any further levels of degradation (van Loon et al., 2018), which informed the upper limit of the pressure intensity scale (SAR >3).

Table 6. *Classification of the swept area ratios per grid cell per year.*

BH3 Category	SAR
None (0)	0.00
Very Low (1)	>0.00 – ≤0.33
Low (2)	>0.33 - ≤0.66
Medium (3)	>0.66- ≤1.00
High (4)	>1.00- ≤3
Very High (5)	> 3.00

To assess fishing pressure over the 2009 to 2020 assessment period, aggregated pressure layers were created, combining annual pressure layers into a single dataset for use in disturbance assessments using a spatial union via Geographic Information Systems (GIS) software. Please see section "**Caveats on assessment of benthic habitat condition**" for caveats on the use of SAR pressure layers.

When combining all annual layers via spatial unions in GIS, there were instances where c-squares had no reported VMS data for specific years in the time series. Therefore, when calculating aggregated SAR values, c-squares without reported VMS were treated as having 'no data', rather than 0 SAR, due to the presence of true 0 values in the annual layers before aggregation. Additionally, it was likely that although certain c-squares had no VMS data reported in select years, they were in areas suitable for bottom contact fishing.

The range of SAR categories observed across the time series was calculated for each c-square, indicating distinction between areas where fishing intensity was at 'Consistent' levels across years, from those where fishing intensity levels fluctuated. C-squares were considered 'Variable' if a range of three or more SAR categories was observed throughout the time series. The use of three or more SAR categories to denote variance originated in the IA 2017 and was based on expert judgement. C-squares that had a variance range of three or more SAR categories were used to indicate areas of opportunistic fishing, potentially new areas being explored for fishing or areas which were not used consistently.

To produce a layer showing the aggregated surface and subsurface pressures that accounted for variations in fishing pressure across years, the following method was used:

- For cells with low variability (i.e., a range of less than three SAR categories), the mean of SAR values across all years with available data was calculated (areas without SAR reported were not analysed as 0 pressure).
- For cells with high variability (i.e., range of three or more SAR categories), the highest SAR value across all years was selected following a precautionary approach to represent the most damaging levels of fishing to benthic habitats (OSPAR, 2017).

Note the mean and maximum SAR values were taken from the raw values in the ICES data (prior to intensity categorisation). The mean and maximum SAR values were then recategorized into the intensity scale (**Table 66**) to give aggregated pressure categories for each c-square. The final pressure layers showing extent and intensity of surface and sub-surface abrasion caused by mobile bottom contacting fishing gears are displayed on **Figure 6**.

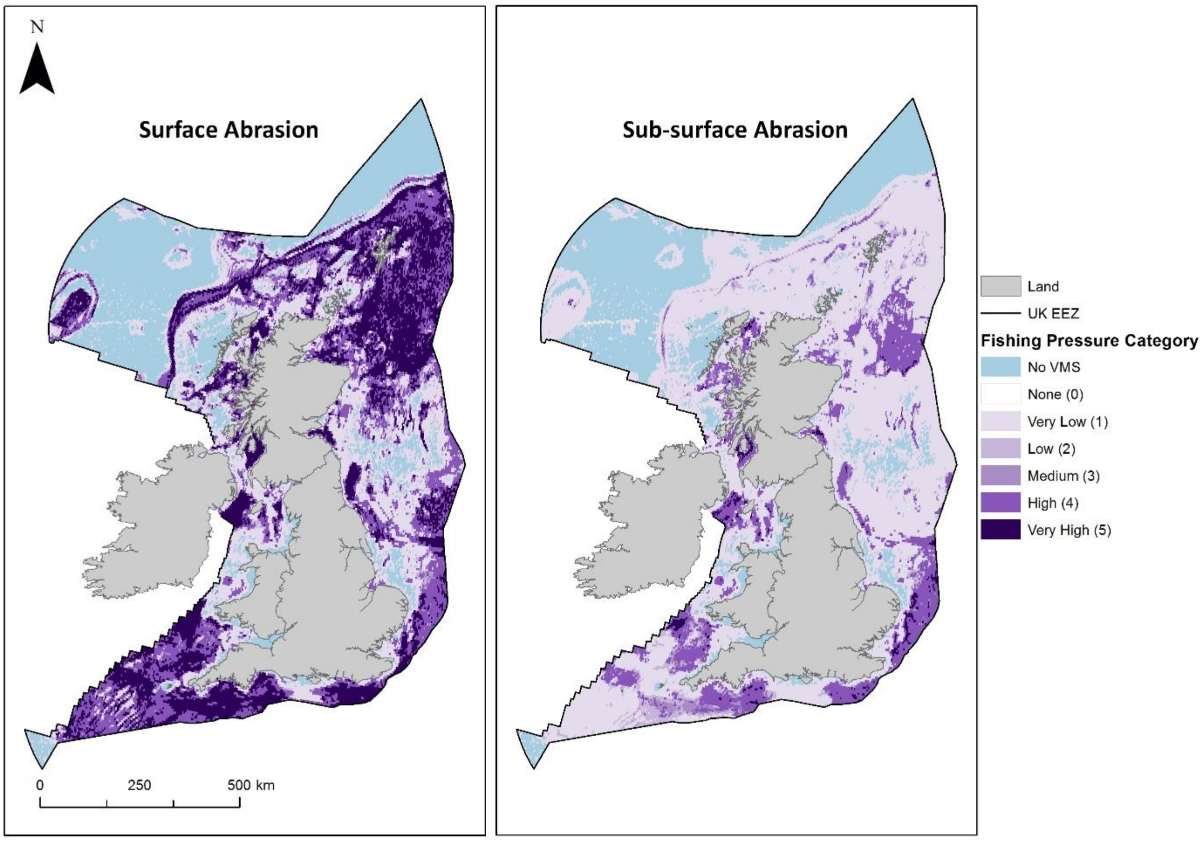

Figure 6. *BH3a pressure map based on VMS data 2009-2020*

Aggregates extraction

Commercial aggregate extraction data for the United Kingdom were sourced in the format annual extraction duration within 50 x 50 m grid cells derived from vessel EMS proved by The Crown Estate and Royal Haskoning for 2009 to 2020.

Aggregate extraction intensity was estimated from calculating the Swept Area Ratio (proportion of a grid cell swept per year, SAR) using Equation 1.

Equation 1. Swept Area Ratio (SAR) calculation for aggregate extraction.

$$\text{SAR} = \frac{\text{Duration} \times \text{Draghead width} \times \text{Vessel speed}}{\text{Area of grid cell}}$$

Where:

- Duration is the annual length of time spent undertaking aggregate extraction (hrs/yr.),
- Draghead width is the width of the equipment on the end of the dredge pipe that is in contact with the seabed whilst extracting aggregates (km),
- Vessel speed is the speed at which the vessel is travelling whilst extracting aggregate (km/hr),
- Area of grid cell is the grid or cell area determined by the resolution of the data (km^2).

Fixed values, derived from literature relevant to extraction activity in the North-East Atlantic, were used for the parameters of vessel speed (2 kt, converted to 3.704 km/hr) and draghead width (3 m, converted to 0.003 km) (**Table 77**).

Table 7. *Summary of trailer dredging extraction activity parameters derived from literature.*

Maximum draghead / furrow width (m)	Source information
1.4	Drabble, 2012 (draghead width)
2.4	Drabble, 2012 (furrow)
2.5	Boyd *et al.,* 2003
3	Kenny & Rees 1994; Boyd & Rees, 2003; Cook & Burton, 2010; Tillin *et al*., 2011; Last *et a*l., 2011; Newell & Woodcock, 2013; BMAPA, 2017; Robson *et al*., 2018
4	BMAPA, 2010; Birchenough *et al*., 2010
Vessel speed	**Source information**
1.5 knots	Tillin *et al*., 2011; Last *et al*., 2011; Newell & Woodcock, 2013; BMAPA, 2017
2 knots	Boyd *et al.,* 2003; Drabble, 2012
2-3 knots	Vlasblom, 2005

The parameters used when calculating SAR are associated with trailer dredging, which was considered the most prevalent method across the UK EEZ. Although other forms of extraction, such as static dredging, were known to occur in the North-East Atlantic, available data from the United Kingdom were not sufficiently detailed to identify specific extraction methods.

For commercial aggregate extraction data to be included in the BH3 assessment, data had to be categorised into an intensity scale to protect commercial data sensitivity. As a preliminary approach, SAR values were categorised into an intensity scale ranging from 1 to 5 (**Table 66**), in line with the method used for bottom-contact fishing, to create annual extraction pressure maps for the years 2009 to 2020. The intensity scale used was discussed and agreed with members of the OSPAR Benthic Habitats Expert Group and industry experts as a suitable preliminary approach to assessing extraction pressure.

To assess extraction pressure from the United Kingdom across multiple years, the same method used for bottom trawling data was applied, aggregating SAR values using the average or maximum value observed during the period 2009-2020 within each grid cell, depending on the interannual variability of the pressure values. However, in contrast to the assessment of fishing pressure, grid cells with no aggregate extraction present in specific years, where extraction activity was present in other years, were treated as 0 pressure. This specific distinction of 0 pressure was made as commercial aggregate extraction is a licensed activity, therefore there was high confidence that the data accounted for all commercial aggregate extraction activity within the UK EEZ. Upon categorising final SAR values representative of pressure across multiple years, all data indicative of raw extraction duration, and uncategorised SAR were removed prior to further analyses to safeguard commercially sensitive information.

Step 4: Calculation of potential disturbance of benthic habitats

Step 4 of the BH3 assessment involved creating a spatial layer that quantified disturbance to species and habitats within the UK EEZ. Sensitivity (outputs of Step 2) and pressure (outputs of Step 3) maps were spatially intersected via Environmental Systems Research Institute (ESRI) ArcGIS software (ESRI, 2012). Potential surface and subsurface disturbance were calculated separately on the intersect output layer by combining corresponding sensitivity and pressure values via a matrix (

Table 88), producing nine categories of disturbance (1–9, where 9 was the maximum risk of disturbance possible). Disturbance categories were summarised into four groups

- 'Zero' = disturbance category 0 or consistent absence of VMS data throughout assessment period,
- 'Low' = disturbance categories 1-4,
- 'Moderate' = disturbance categories 5-7,
- 'High' = disturbance categories 8 and 9

In instances where pressure data intersected areas without sensitivity information (due to a lack of EUNIS habitat data or sensitivity assessments), outputs were classified as 'Unassessed Disturbance'. Note that these groupings are not representative of thresholds and should be used for comparative interpretations of disturbance outputs across the UK EEZ only.

Table 8. Disturbance matrix with summary groups; 'Low' (1-4), 'Moderate' (5-7), and 'High' (8-9). Note 'Zero'* = No reported VMS data or 0 SAR value reported by ICES for vessels >12 m only.

Disturbance matrix		**Sensitivity**				
		1	2	3	4	5
	Null / 0*	0	0	0	0	0
Pressure	1	1	2	3	4	6
	2	1	2	4	6	7
	3	1	3	5	7	9
	4	1	4	6	8	9
	5	2	4	7	9	9

Results

Disturbance from Bottom Trawling (BH3a)

Approximately a quarter of the UK EEZ had 'Zero' disturbance from bottom-contacting fishing gear for the assessment period 2009 to 2020 (Error! Reference source not found.**9**). 'Zero' disturbance was predominant in 'Deep-sea' (A6) habitats (Error! Reference source not found. and **Annex Table 1)** mainly where bottom-contact fishing activity may not occur due to the greater depth range of the habitats. Over 40% of the total area had 'Moderate' or 'High' disturbance (Error! Reference source not found.**9**), predominantly occurring in 'Sublittoral sediment' (A5) habitats (Error! Reference source not found. and **Annex Table 1)**. Assessments of disturbance were not calculated in OSPAR Region I and Region V, which accounted for approximately 3,400 km^2 of the UK EEZ area (<0.5% of the total area; Error! Reference source not found.**9**). In addition, disturbance could not be calculated where habitat data were not available, which accounted for approximately 1% of the UK EEZ.

Table 9. *Percentage of the total area of the UK EEZ under the following disturbance groups from bottom-contacting fishing pressure between the 2009 to 2020 assessment period: 'Zero' = disturbance category 0; 'Low' = disturbance categorise 1-4; 'Moderate' = disturbance categories 5-7; 'High' = disturbance categories 8 and 9; 'Unassessed Disturbance' = area where fishing pressure was present but disturbance could not be assessed due to i) no habitat data, or ii) no sensitivity assessments for underlying habitat; 'Area not relevant' = Areas not assessed by BH3a (OSPAR Regions I & V).*

Disturbance Group	Percentage of UK EEZ Area

Zero	25.83%
Low	31.39%
Moderate	26.41%
High	14.77%
Unassessed Disturbance	1.1%
Area not relevant	0.49%

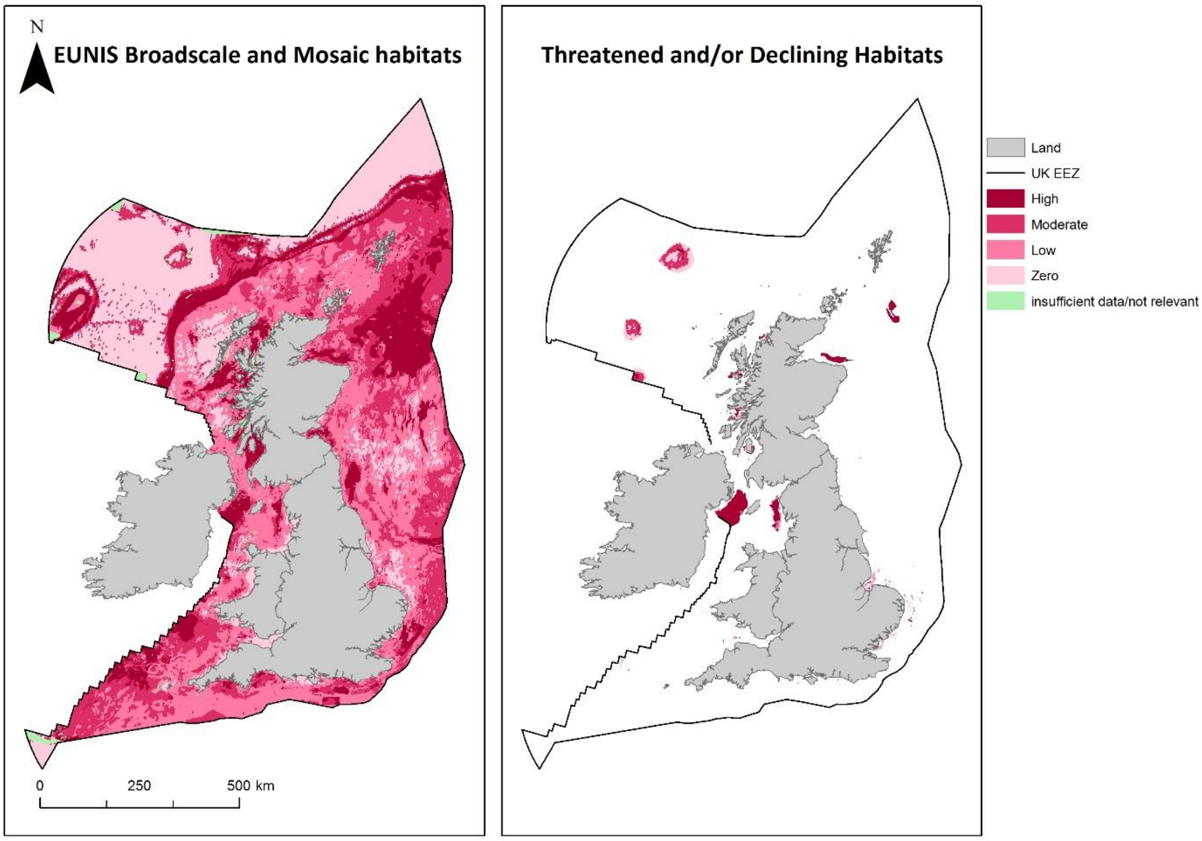

Figure 7. *BH3a map of disturbance from bottom-contacting fishing gears on EUNIS broadscale and mosaics habitats and on Threatened and / or Declining Habitats.*

Variability in disturbance coverage was observed among the different habitat types assessed across the UK EEZ (**Error! Reference source not found.**, **Annex Table 1**). However, the majority of Sublittoral sediments (A5 EUNIS codes) had widespread disturbance across more than 50% of area each habitat individually. Sublittoral mud (A5.3) had the greatest proportion of habitat area under disturbance when considering all distinct (non-mosaic) habitat types assessed and ‘Zero’ disturbance was present in 3% of the habitat area.
Furthermore, ‘Zero’ disturbance was present in less than 10% of Sublittoral coarse sediment (A5.1) and Sublittoral sand (A5.2), and 12% of Sublittoral mixed sediments (A5.4). In contrast to areas of widespread disturbance, the majority of Deep-sea habitats (A6 EUNIS codes) had more than 50% of their area categorized as ‘Zero’ disturbance, with the exception of Deep-sea sand and Deep-sea muddy sand mosaic (A6.3 &A6.4; 26% in ‘Zero’ disturbance), and undefined Deep-sea bed (A6; 32% in ‘Zero’ disturbance).

More substantial variations in the intensity of disturbance were apparent among habitats across the UK EEZ (**Figure 8** ,**Annex Table 1**). Sublittoral mud had the greatest proportion of habitat area under both ‘High’ and / or ‘Moderate’ disturbance of all distinct (non-mosaic) habitats, as well as the greatest proportion of habitat area with ‘High’ disturbance alone (83%). ‘Moderate’ disturbance alone covered the greatest proportion of distinct habitat area of Sublittoral sand (58%), which also had the greatest extent within the UK EEZ (238054.94 km^2). Sublittoral biogenic reefs (A5.6) were under ‘Moderate’ or ‘High’ disturbance in 45% of the habitat area **Annex Table 1).** High disturbance was also observed in Deep-sea broad-scale habitats and most prevalent in the mosaic Deep-sea sand/Deep-sea muddy sand (A6.3&A6.4) and in deep sea habitats recorded at level 2 of the EUNIS classification (A6)

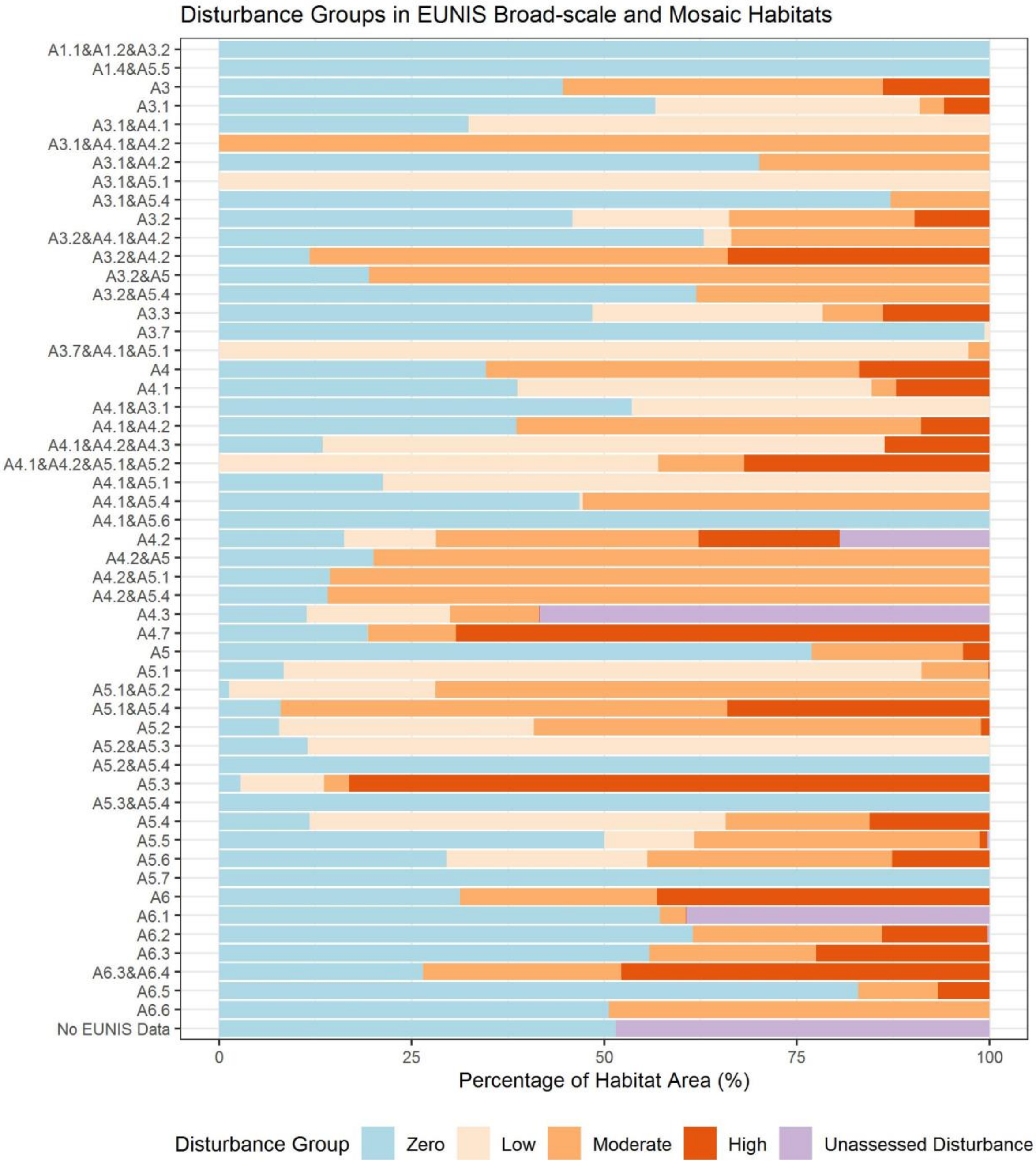

Figure 8. *The percentage of EUNIS broadscale and mosaic habitats in each of the following disturbance groups from bottom-contacting fishing gear in the 2009 to 2020 BH3 assessment: ‘Zero’ = disturbance category 0; ‘Low’ = disturbance categories 1-4; ‘Moderate’ = disturbance* categories 5-7; ‘High’ = disturbance categories 8 and 9; ‘Unassessed Disturbance’ = area where fishing pressure was present

but disturbance could not be assessed due to i) no habitat data, or ii) no sensitivity assessments for underlying habitat.

Varying extents of overall disturbance and disturbance intensity were observed in reported OSPAR Threatened and / or Declining Habitats. Disturbance was most widespread in 'Sea-pen and burrowing megafauna communities' which had both the greatest reported habitat area and the largest ratio of 'High' disturbance (87%; Error! Reference source not found.**8** and **Annex Error! Reference source not found.2**). 'Seamounts' were the second largest OSPAR Threatened and / or Declining Habitat area, with over 50% or reported area recorded as 'High' disturbance. Disturbance was present in 75% of '*Sabellaria spinulosa* reef' habitat, predominantly in the 'Low' disturbance group. Both 'maerl beds' and '*Lophelia pertusa* reefs' had relatively small reported areas (less than 75 km^2 and 28 km^2 respectively), although, both had over 60% of their total area in 'Moderate' or 'High' disturbance groups (**Figure 9**). Disturbance results in shallow / intertidal habitats (e.g., 'Littoral chalk communities') should be treated with lower confidence, due to the lack of VMS data from vessels less than 12 m and in some instances pressure within the c-square was potentially occurring outside of the intersecting habitat.

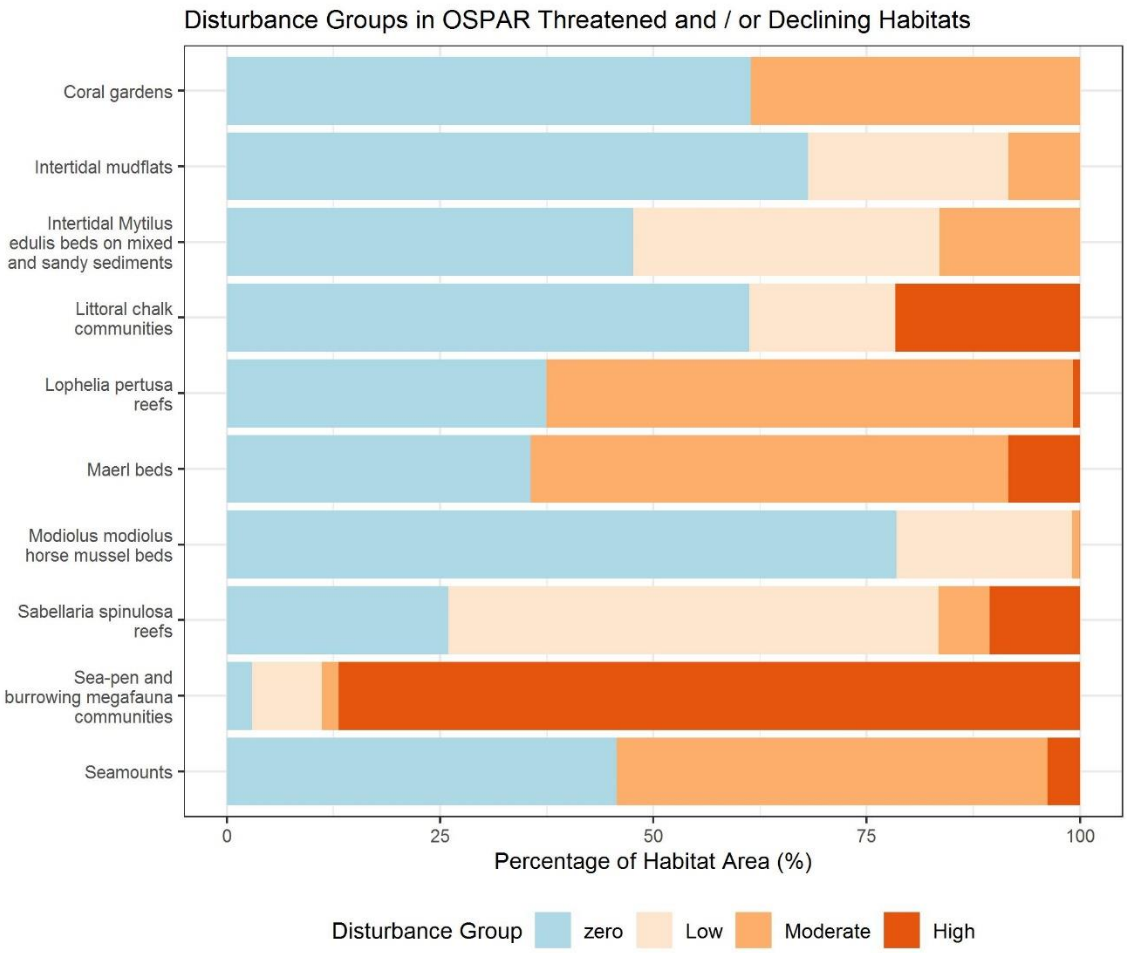

Figure 9. *The percentage of each OSPAR Threated and / or Declining Habitat's area under each of the following disturbance groups from bottom-contacting fishing gear in the 2009 to 2020 BH3a assessment: 'Zero' = disturbance category 0; 'Low' = disturbance categories 1-4; 'Moderate' = disturbance* categories 5-7; 'High' = disturbance categories 8 and 9.

Disturbance from Aggregate Extraction (BH3b)

Aggregate extraction disturbance in the UK EEZ

The percentage of the total area of the UK EEZ under disturbance from extraction pressure between 2009 to 2020 was minimal, occurring in discrete areas around England and Wales (**Table 10** and Error! Reference source not found.). 'High' disturbance was the most prevalent disturbance group (0.019%) closely followed by 'Low' disturbance (0.017%) and finally, 'Moderate' disturbance (0.006%). Additionally, a small percentage (<0.001%) of the UK EEZ was analyzed as 'Unassessed disturbance' as extraction pressure was present but there was an absence of habitat and / or sensitivity information.

Table 10. *Percentage of the total area of the UK EEZ under the following disturbance groups derived from marine aggregate extraction pressure between the 2009 to 2020 assessment period: 'Zero' = disturbance category 0; 'Low' = disturbance categorise 1-4; 'Moderate' = disturbance categories 5-7; 'High' = disturbance categories 8 and 9; 'Unassessed Disturbance' = areas where extraction activity occurred but there was an absence of habitat and / or sensitivity data.*

Disturbance Group	Percentage of UK EEZ Area
Zero	99.958%
Low	0.017%
Moderate	0.006%
High	0.019%
Unassessed Disturbance	<0.001%

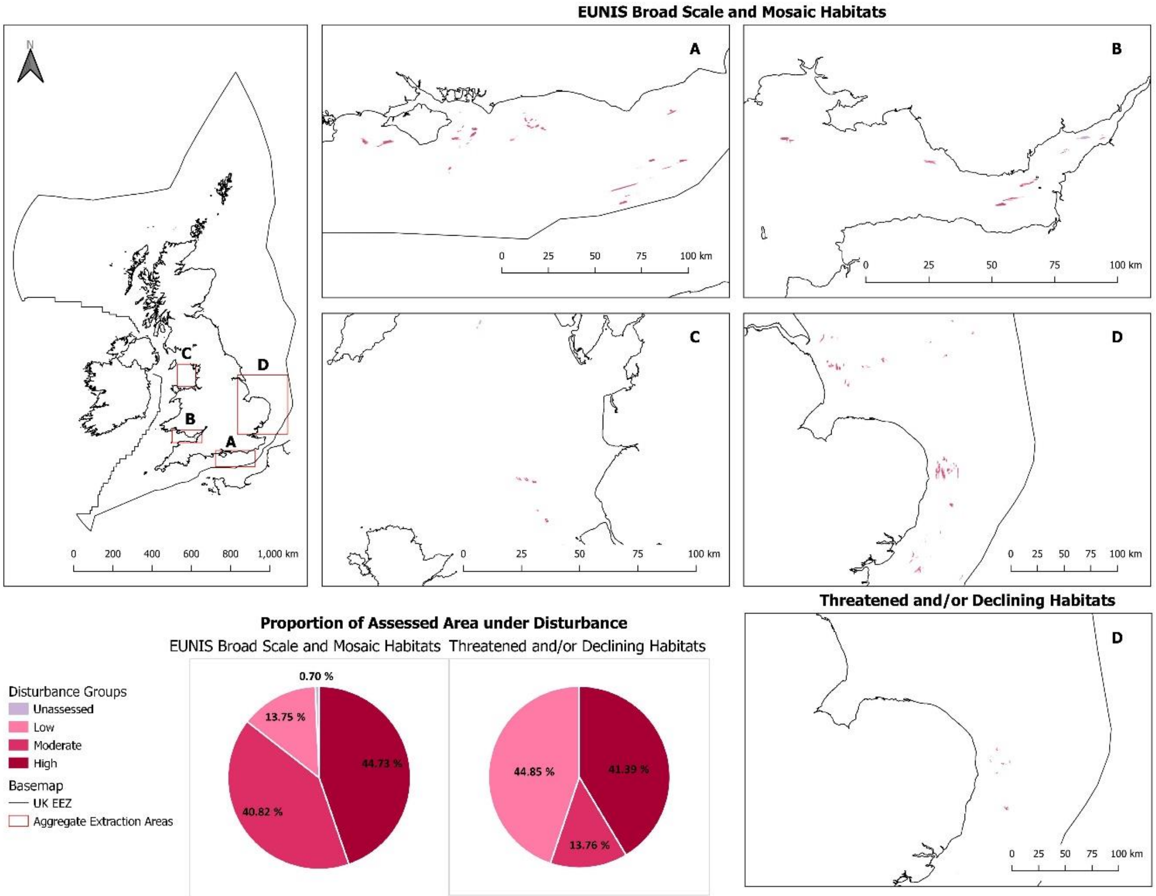

Figure 10. *BH3b map of disturbance from Aggregate extraction on EUNIS broadscale habitats and on Threatened and / or Declining Habitats.*

The only OSPAR Threatened and / or Declining Habitat that intersected with extraction pressure was '*Sabellaria spinulosa* reefs' in the Southern North Sea, mostly under 'Low' levels of disturbance (44.85%) (**Error! Reference source not found.**, D). Approximately 1.5% of OSPAR reported '*Sabellaria spinulosa* reef' area was present in areas of extraction pressure (12.8 km^2 of 842.68 km^2).

<u>Aggregate extraction disturbance within EUNIS broad-scale habitats</u>

Aggregate extraction activity affected seven broad-scale habitats, as well as some areas of undefined Sublittoral sediment (A5) and areas where EUNIS data were not available (**Annex** Error! Reference source not found.**3** and **Figure 11**). However, the percentage of total broad-scale habitat area within the UK EEZ affected by aggregate extraction disturbance was minimal (Error! Reference source not found.**0** and **Figure 11**). Sublittoral biogenic reefs (A5.6) had the greatest percentage of 'High' disturbance (1.029%), as well as the greatest percentage of total disturbance (1.792%)**.** Sublittoral mixed sediments (A5.4) and Sublittoral coarse sediments (A5.1) had the second and third greatest levels of 'High' (0.088% and 0.056%) and total disturbance (0.249% and 0.126%), respectively.

Aggregate extraction can often take place in areas of mixed sediment where the tube-building polychaete *Sabellaria spinulosa* can occur (OSPAR, 2010). Such areas correspond with the EUNIS habitat *Sabellaria spinulosa* on stable circalittoral mixed sediment (A5.611), a child biotope of Sublittoral biogenic reefs. Furthermore, disturbance levels in Sublittoral mixed sediments and Sublittoral coarse sediment aligned with these habitats containing sand and gravel materials that are directly targeted by the commercial aggregate extraction industry.

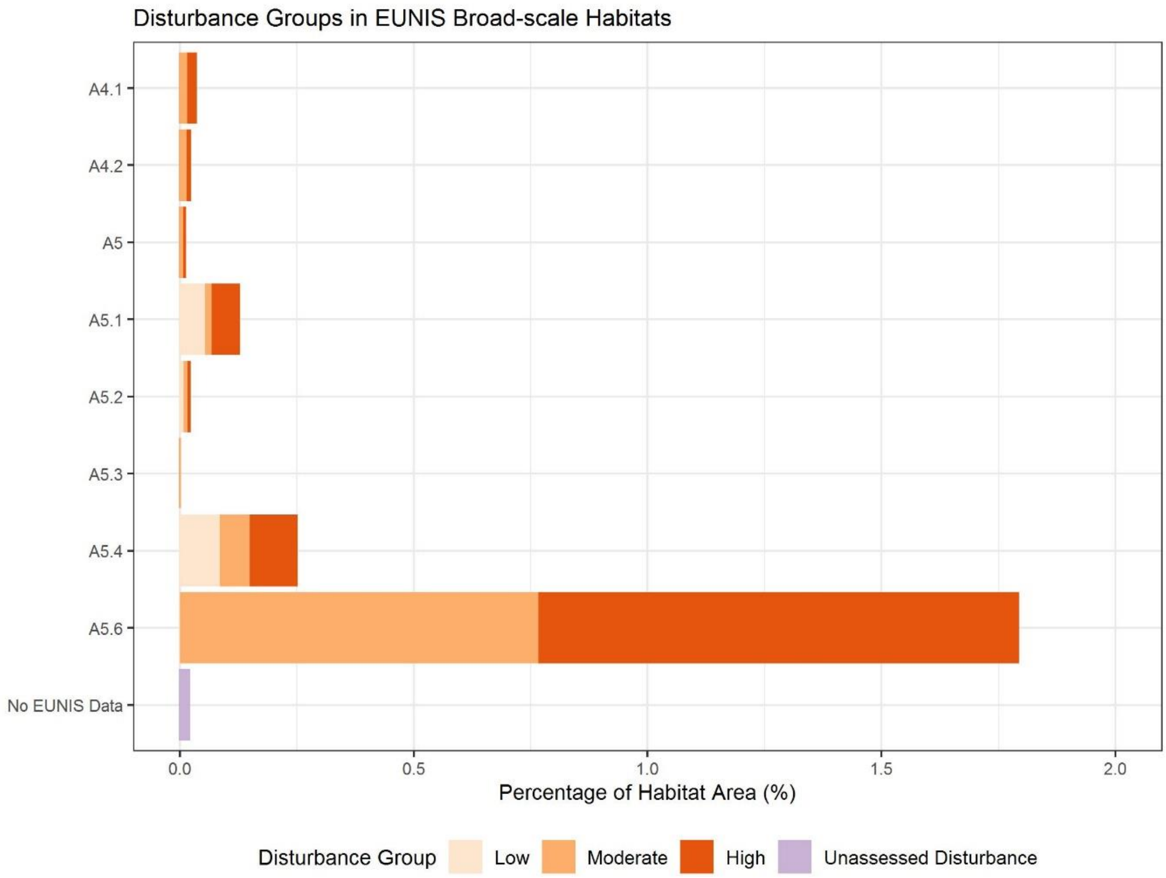

Figure 11. *The percentage of EUNIS broad-scale area in each of the following disturbance groups derived from Aggregate extraction in the 2009 to 2020 BH3b assessment: 'Low' = disturbance categorise 1-4; 'Moderate' = disturbance categories 5-7; 'High' = disturbance categories 8 and 9; 'Unassessed Disturbance' = areas where extraction activity occurred but there was an absence of habitat and / or sensitivity data. Note that 'Zero' disturbance is not shown due to the small extent of extraction pressure.*

Relative Benthic Status indicator

The Relative Benthic Status (RBS) is an indicator of benthic habitat condition derived using the Population Dynamic (PD) model developed and described in (Pitcher et al., 2017). In brief the PD method is a mechanistic model based on the logistic population growth equation generally applied in ecology and fisheries to describe how populations change in size in response to exploitation. This method combines fishing pressure data with benthic fauna biomass data and gear-specific depletion (d) and trait-specific recovery (r) parameters to compute a RBS score, which quantifies the benthic biomass remaining after trawling relative to the carrying capacity on a scale of zero to one, zero being the most altered state (**Figure 12**).

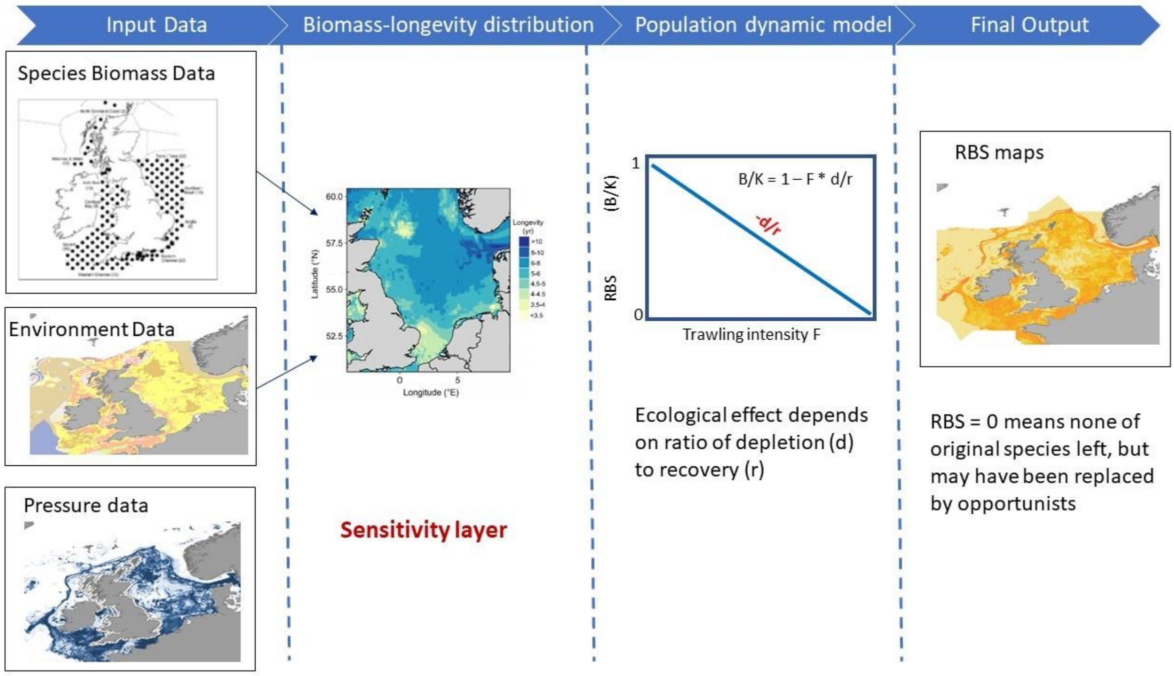

Figure 12. *Overview of the steps involved in the Relative Benthic Assessment methodology (ICES FBIT). Figure adapted from overview of BH3 method.*

The RBS indicator is computed in four steps, detailed in the ICES FBIT working group reports and discussed in more detail below:

1. Preparing quantitative input data
2. Assigning the area of interest
3. Estimating longevity-biomass composition of the benthic community across the study area
4. Estimate seabed state and impact

Step 1: Preparing quantitative input data

The RBS assessment methodology relies on the availability of certain quantitative information for the area under assessment. The data gathered for the RBS completed herein include comprehensive biomass data for benthic infauna and epifauna; appropriate environmental variables originating from benthic species samples and broadscale modelled estimates; species longevity information; and fishing effort data for the mobile bottom contacting gear occurring within the assessment area.

Benthic fauna biomass data

Benthic species biomass data was collected from a variety of organizations across the UK (**Table 11**). Organizations were asked to submit primary data records of benthic infauna and epifauna biomass which had a recorded species name, location (latitude & longitude), biomass and environmental data collected at the same time as the fauna data (e.g. depth, bottom water temperature). Data submitted were incorporated into a standardized Heriot-watt biomass database. The biomass databases provided the RBS assessment with 188,589 data points, from 3,243 sample locations across the UK EEZ (**Figure 13**). In general, benthic samples were collected via grabs but some trawl data was used (**Table**), providing a diverse range of epi- and infauna species.

Fauna longevity data

A longevity-trait matrix was developed which was linked to the fauna biomass database by the species name. Species names from the biomass samples were first standardised using the World Register of Marine Species (WoRMS). Longevity is defined here as the Maximum reported life span of the adult stage, and longevity trait data was obtained from a trait database developed by (Bolam et al., 2020). Whenever data was reported for taxonomic levels higher than species or genus (i.e., order, class, phylum) the data was not included as it was not possible to assign biological traits accurately at these taxonomic levels. From the primary data collection, 5% of taxa recorded did not have associated longevity information, and 10% were not recorded to either genus or species level but family or higher and therefore specific longevity traits were undetermined. A total of 158,043 data points (out of a total of 188,589) were left following exclusion of samples with no traits data. Four longevity modality classes were included in the analysis: <1 year, 1–3, 3–10, and >10 years. Each taxon was coded using a "fuzzy coding" approach as many taxa display multi-faceted behaviour depending upon, for example, prevailing environmental conditions and local resource availability. Traits were coded for a scoring range of 0–3, where 0 conveys no affinity, 1 or 2 express partial affinity and 3 indicates total and exclusive affinity (Bolam et al., 2014). When all taxa had been coded for the species by trait matrix, the codes were converted to proportions for each taxon so that the total for each trait = 1.

The resulting species longevity-trait matrix was merged with the biomass datasets, using the species name contained within both datasets. For these data points fauna biomass was multiplied by fuzzy coded trait data, and fractional biomass for each longevity class and station was created. This station by traits matrix provided the proportional biomass-weighted longevity for all sample stations in the combined biomass-longevity-trait database. The approach described herein follows (Rijnsdorp et al., 2018).

Table 11. *Biomass benthic data providers for SMMR WP1.*

Data provider	Study	Sampling methods	Sampling years
Centre for Environment, Fisheries, Agricultural Science (CEFAS)	(Bolam et al., 2020)	Hammon grab Day grab	2000-2010
CEFAS	(Bolam et al., 2010)	Hammon grab Day grab	2000-2010
Joint Nature Conservation Committee (JNCC)	Tacoi stage 3	Hammon grab (and camera) Day grab Box corer Vanveen grab Beam trawl	2012-14
JNCC	Tacoi stage 2	Hammon grab (and camera) Day grab Box corer Vanveen grab Beam trawl	2014-16
JNCC	Swallow sand survey	Hammon grab	2018
Marine Scotland	Wee Bankie survey	Beam trawl	2015
(Howarth et al., 2018)	(Howarth et al., 2018)	Grab and Beam trawl	2015-16
EMODnet	Multiple	Unknown grab	2010-2017
MERMAN	Multiple	Day grab Box corer	2001-2017

		Vanveen grab Collected by hand Unknown grab	
Plymouth Marine Laboratory (PML)	Multiple	Box corer Day grab	2008-2019
Scottish national heritage	Firth of Clyde 2012	Day grab	2012
International Council for Exploration of the Sea (ICES) Datras	BTS & NS-BTS	Beam trawl	2009-2019

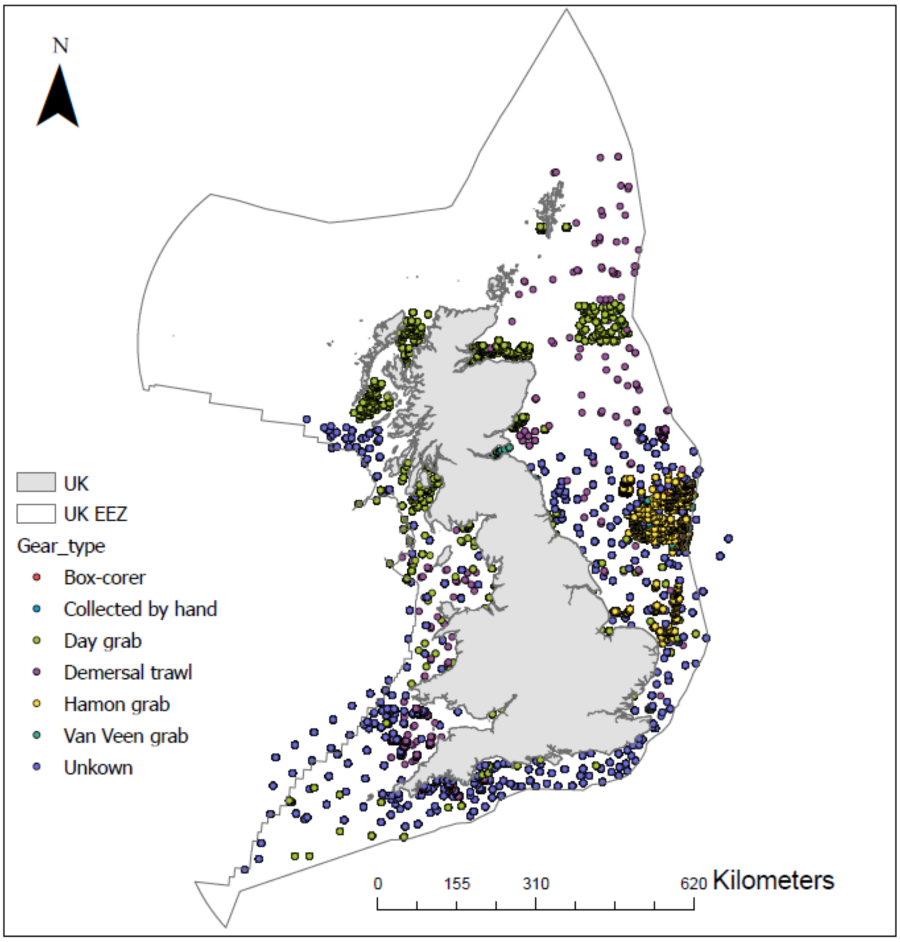

Figure 13. *SMMR WP1 assessment area, the UK EEZ, detailing the distribution of sample locations from which benthic biomass and available environmental attributes were provided.*

Environmental variables data

Environmental data corresponding to each fauna biomass sample was also requested from data providers. The environmental variables included in the database were, habitat type (EUNIS classification), sampled depth (bathymetry in meters), sediment grain size composition (% sand, % mud, %gravel), near bottom water temperature (°C), sea surface primary production (mg C/m^3/d) and bottom water oxygen concentration (mol^{-3}) (**Table 12**). When data was not provided for the selected environmental variables, data was extracted from publicly available modelled or predicted data layers (**Table 1212**). For biomass data points close to inshore regions, the environmental variable data layers could not always provide precise values, so the nearest value (spatially) was used. All the environmental data collected per sample site was incorporated into a separate excel file and linked to the biomass dataset via the sample identifier (ID) code.

Table 12. *Overview of environmental variables used for the Relative Benthic Status assessment, the origin of the data and any temporal limitations.*
**Habitat types were used for summarising results only*

Environmental variable	Data provider	Sampling years
Habitat type*	EMODNET	EUSeaMap 2021 EUNIS habitat classification
Bathymetry (Bathy)	Bio-oracle (Assis et al., 2018; Tyberghein et al., 2012)	2021 Map version
Mean bottom water oxygen (O2_mean)	Copernicus Climate Data Store	Annual prediction for the c-square in the year the faunal sample was taken
Mean sea surface primary production(SurfPP_mean)	Copernicus Climate Data Store	Annual prediction for the c-square in the year the faunal sample was taken
Mean bottom water temperature (Temp_mean)	Copernicus Climate Data Store	Annual prediction for the c-square in the year the faunal sample was taken
Gravel content (Gravel)	(Wilson et al., 2018)	Various primary data sources 1993-2016
Sand content (Sand)	(Wilson et al., 2018)	Various primary data sources 1993-2016
Mud content (Mud)	(Wilson et al., 2018)	Various primary data sources 1993-2016
Swept-Area-Ratio	(ICES, 2019)	Decadal average 2009-2020
Swept-Area-Ratio	(ICES, 2019)	3-year average up until the year before the biomass sample was recorded

Bottom fishing pressure layer (swept-area-ratio)

Information on fishing pressure for the UK EEZ was available through the International Council for Exploration of the Sea (ICES) for the years 2009-2020 (ICES, 2021) on a 0.05 x 0.05 degree c-square resolution for all Mobile Bottom Contacting Gear (MBCG) (**Table 13**). Fishing pressure is quantified as a Swept Area Ratio (SAR) value which quantifies the number of times a c-square area of the seabed is impacted by MBCG. SAR is calculated using Vessel Monitoring Systems (VMS), the vessel size, and the gear used (Eigaard et al., 2016b). A SAR value of 0 means that the c-square grid area has had no recorded fishing activity. A SAR value of 1 means that the entire c-square has been swept once (within the data given calendar year). SAR data is provided for <2cm sediment depth (SurfaceSAR) and ≥2cm (SubsurfaceSAR), for this analysis SurfaceSAR, was used because the RBS assessment already accounts for the associated penetration depth of different MBCG (Rijnsdorp et al., 2018). In order to determine the fishing pressure at the time when each fauna sample was collected, an average was calculated from the preceeding three years of SAR for all MBCG combined. Where SAR values were not available for the sample year as in the case of fauna samples collected prior to 2009, the averaged total from all MBCG types from 2009-2020 was used. Any c-squares within the UK EEZ which contained undisclosed SAR values (i.e., the value of SAR appeared as -9999) were removed.

Table 13. *Glossary terms and BENTHIS métier groupings used to define higher level métier groupings (ICES, 2021).*

Surface SAR	< 2 cm penetration depth of the gear components.
Beam trawl (TBB)	For beam trawls (TBBs) the footprint consists of two components: (i) the shoes of the beam, and (ii) the ground gear. Before that part of the footprint is made by the tickler chains of the trawl, if such chains are deployed.
Dredge (DRB)	For dredges (DRBs) the ground gear component defines the footprint which is homogeneous across the entire width of the dredge, even if teeth are used.
Demersal Seine (DS)	For seines (DSs) two main types of footprint occur: (i) from the seine rope, and (ii) from the seine ground gear.
Otter Trawl (OT)	For otter trawls (OTs), the footprint is composed of (i) the otter boards, (ii) the sweeps, and (iii) the trawl ground gear.

Step 2: Assigning the area of interest

The area under assessment herein is the UK Economic Exclusion Zone (EEZ). The RBS assessment is initiated by building a bargrid to an appropriate scale in R. The bargrid was built starting from -16.97 (latitude), 48.025 (longitude), with 0.05-degree sized squares at a 600 by 300 square scale. The squares, termed c-square by ICES, are coded and act as unique spatial identifiers, allowing other environmental variables to be combined with the bargrid. The 0.05-degree sized c-square was used to align with the fishing pressure layers from ICES. The resulting bargrid was then clipped to the UK EEZ.

The bargrid, and extrapolations made in later stages of the RBS assessment, have been spatially limited by the spatial extent of the environmental data (**Figure 14**). The Generalised Linear Model (GLM) selected in Step 3 identified SAR, mean depth and sand content (**Table 12**) as statistically significant variables for predicting the actual longevity distributions in regions where there has been no primary data collected. Given that it is not possible to estimate longevity in areas where these key environmental parameters are missing, the bargrid does not cover the entire extent of the UK EEZ but mirrors where data is available for SAR (ICES, 2021), sand content (Wilson et al., 2018) and mean depth (Bio-oracle) ((***Figure 14*****a**, **b** and **c** respectively). The extent of the study area is shown by the bar grid in ***Figure 14*****d**.

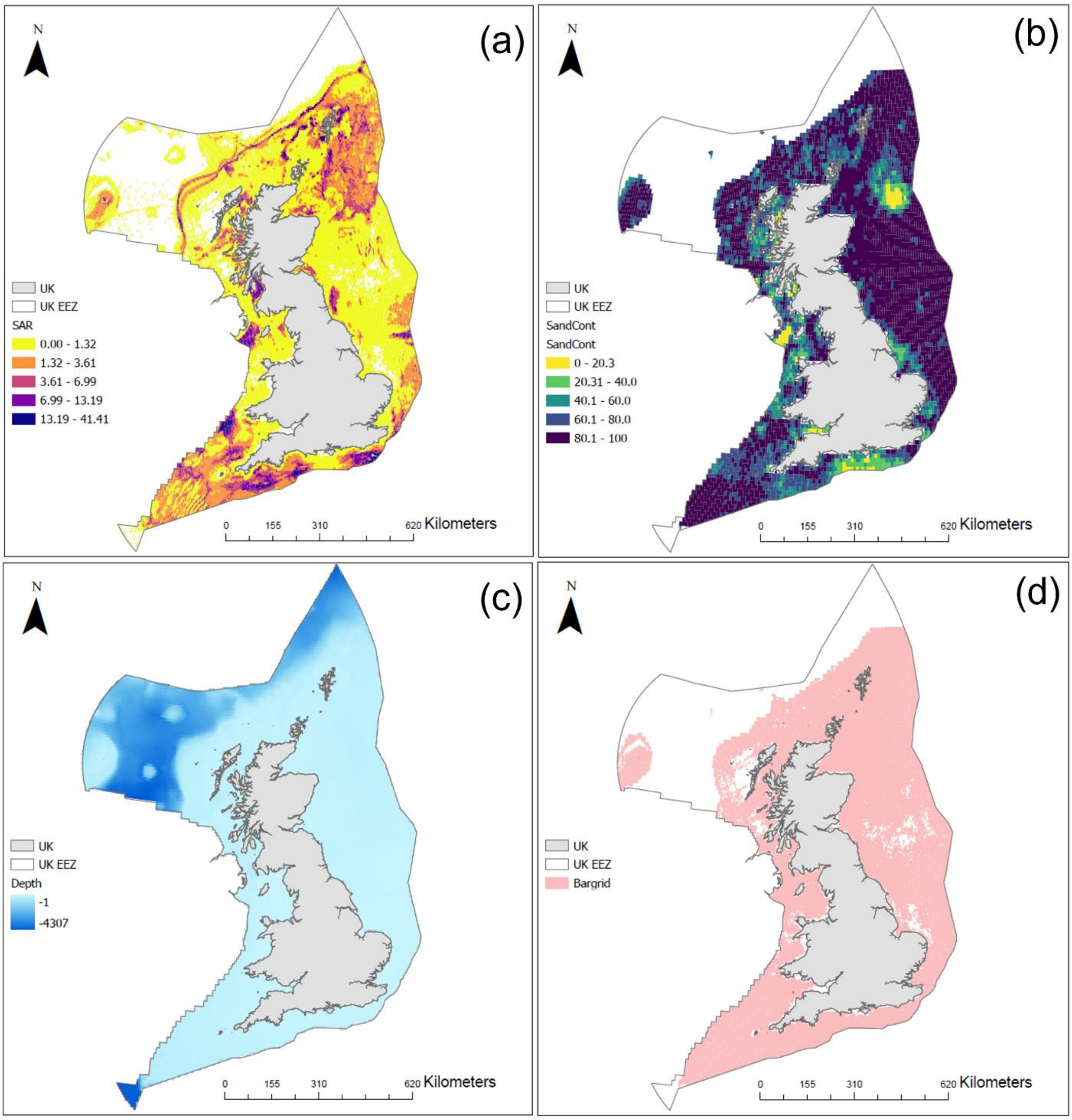

Figure 14. *The key environmental variables identified by Generalised Liner Models (GLMs) in Step 3 which restricted the bargrid spatial scale are (a) Swept Area Ratio (average 2009-2020; (ICES,2021)), (b) Sand content (% ; (Wilson et al., 2018)), and (c) [mean depth](#) (in meters). (d) depicts the final bargrid, which is the areal extent for which the Relative Benthic Status can be calculated.*

Step 3: Estimating longevity-biomass composition of the benthic community

This step predicts the longevity–biomass composition of the benthic community across the study area using the relationship between species biomass data, longevity data and different environmental variables. The RBS assessment methodology recommends that the estimation of the longevity-biomass composition is carried out using only sampling locations that are largely undisturbed (i.e., SAR = 0, <0.5 or <1) to derive a reference state (i.e., no fishing) composition. However, very few of our data-points were in unfished areas, selecting areas with a SAR of <0.5 resulted in a loss of 97.5% sample stations. Therefore, all data points were retained, and the fishing pressure (SAR) was included as a predictor variable in this step.

To statistically estimate the longevity composition in relation to environmental drivers, we converted the biomass by longevity to a cumulative biomass by calculating the biomass proportion with longevity that is smaller than or equal to 1, between 1 - 3, and between 3 - 10 years in each location. We assumed, following Rijnsdorp et al. (2018), that the shape of this cumulative biomass proportions—longevity relationship is sigmoidal (logistic), which starts at 0 and approaches 1 when longevity becomes large. The biomass–longevity relationship was analysed using a statistical model, with the cumulative biomass proportions (Cumb) as the response variable and longevity (l), mean depth (depth), SAR (SAR), sand content (sand), mud content (mud) and gravel content (gravel) as the predictor variables (see model 1 in **Table 14**). A linear mixed effect model was used, with a random intercept per sample ID and sampling device used (producing epifauna or infuana samples).

We examined main effects and two-way interaction terms in all statistical procedures with model fits being evaluated using the Akaike Information Criterion (AIC). The best candidate model, i.e., lowest AIC, yet with a difference of <2 AIC units, was chosen to extrapolate the longevity distribution using the environmental conditions (**Figure 14**) on a UK EEZ-wide scale (0.05 - 0.05 degrees c-square). In total twenty-three models were tested (**Annex Table 4**). Model number 15 (**Table**) was used to estimate mean longevity across all c-squares in the bargrid (**Figure 15**).

Table 14. *Generalised Linear Model (GLM) output for the Relative Benthic Status assessment: (mod1) the full model with all parameters; (mod15) the selected model with lowest Akaike Information Criterion (AIC). The full model selection process used in the RBS analysis to predict longevity using habitat conditions for the total community is detailed in Annex 1: GLM model selection.*

Model number	**Model parameters**	**AIC**
mod1	**Full model** Cumb ~ ll + depth + SAR + mud + sand + gravel + depth:ll + gravel:ll + SAR:ll + (1| ID) + (1| sampling device)	5950.152
mod15	Cumb ~ ll + depth + SAR + sand + (1| ID) + (1| sampling device)	5941.179

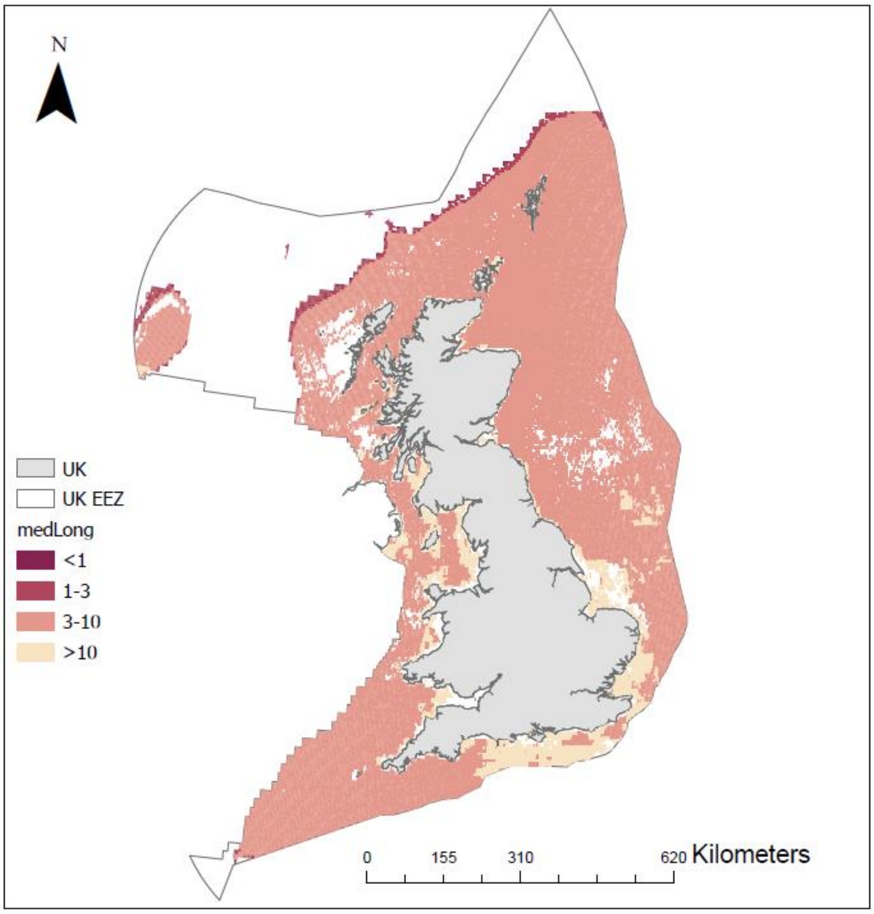

Figure 15. *Modelled mean community longevity of benthic biota per c-square for the UK EEZ bargrid area.*

Step 4: Estimate seabed state and impact

To estimate the seabed state and impact of fishing, the output from step 3 (modelled longevity) was combined with the decadal average of trawling pressure from different gear types to understand how benthic communities, per c-square, are impacted. The premise of the analysis is based on work conducted by Jennings & Kaiser, 1998 demonstrates habitats in more stable environments are populated by species with increased longevity and experience longer recovery times. Whereas highly disturbed habitats, naturally or anthropogenically, are typically inhabited by species with shorter longevity traits and can recovery quicker. Hiddink et al., 2017; Pitcher et al., 2017; Rijnsdorp et al., 2016 quantitatively culminated this work by combining studies on the relationship between depletion of community longevity, fishing pressure, penetration depth and recovery rates into an applied model.

The RBS of the community following trawling is calculated for each c-square, by solving the below logistic population growth model derived by (Pitcher et al., 2017):

$$Community\ \ state = \frac{B}{K} = 1 - F\frac{d}{r},$$

where B is the faunal biomass, K is the carrying capacity, F is the bottom trawling intensity per year, d is the proportional depletion of benthic biomass caused by a single trawl pass and is gear specific, and r is the intrinsic growth rate per year of the benthic community and is longevity trait-specific. Gear specific depletion values (d) were derived from a global meta-analysis (Hiddink et al., 2017), where d is 0.14 for beam trawls (TBB), 0.06 for otter trawl (OT), 0.2 for towed dredges (TD) and are summed per c-square. The depletion rate for demersal seine (DS) was set at the lowest depletion rate estimated for otter trawls (0.06) as these gars are expected to have similar penetration depths as otter trawls. The RBS methodology developed by (Pitcher et al., 2017) applies an intrinsic growth rate (r) of the community r that is independent of the type of fishing gear, because the mechanism of recovery, i.e., recruitment and growth following mortality, is assumed to differ between species with different longevity but not between different fishing gear. Recovery rates are derived from field estimates of a global meta-analysis of recovery after trawling disturbance, where recovery is shown to be dependent on longevity (recovery rate per year = r = H/longevity, with H = 5.31, Hiddink et al., 2019).

The RBS assessment estimates the status of the marine community strucutre, relative to its status prior to a fishing disturbance event. The modelled RBS output is presented on a 0-1 continuous scale, where 1 represents an unimpacted benthic community and 0 means none of the original community structure is left. Although a low RBS score indicates the original community is degraded, it could have been re-populated by a new community assemblage, likely comprised of opportunistic species with high recovery rates.

All geospatial and statistical calculations were conducted in ArcGIS Pro and R4.2.1

Results

The predicted state of the benthic community in response to fishing pressures from MBCG is shown in **Figure 16**. Analysing the distribution of RBS output per cumulative fractional area of the bargrid, showed that 20% of the study area has an RBS value of less than 0.76 (RBS output), 21 - 40% of the study area has an RBS between 0.77 - 0.90, 41 - 60% has an RBS between 0.91 - 0.97, and 61 - 80% of the study area has an RBS between 0.98 - 0.99 (

Figure 17). The areas of lowest RBS outputs mirror areas of high SAR (**Figure 14(a)**).

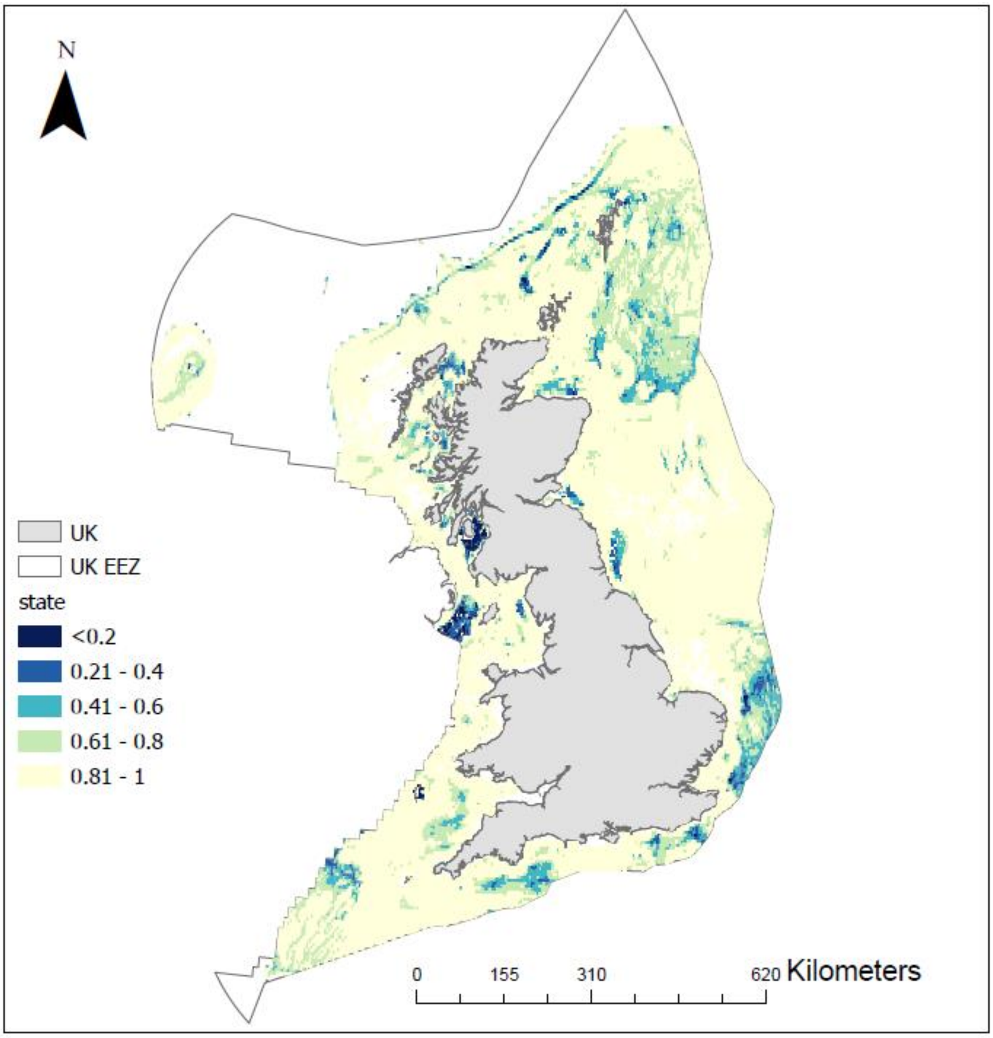

Figure 16. Modelled Relative Benthic Status (RBS) output per c-square for the UK EEZ.

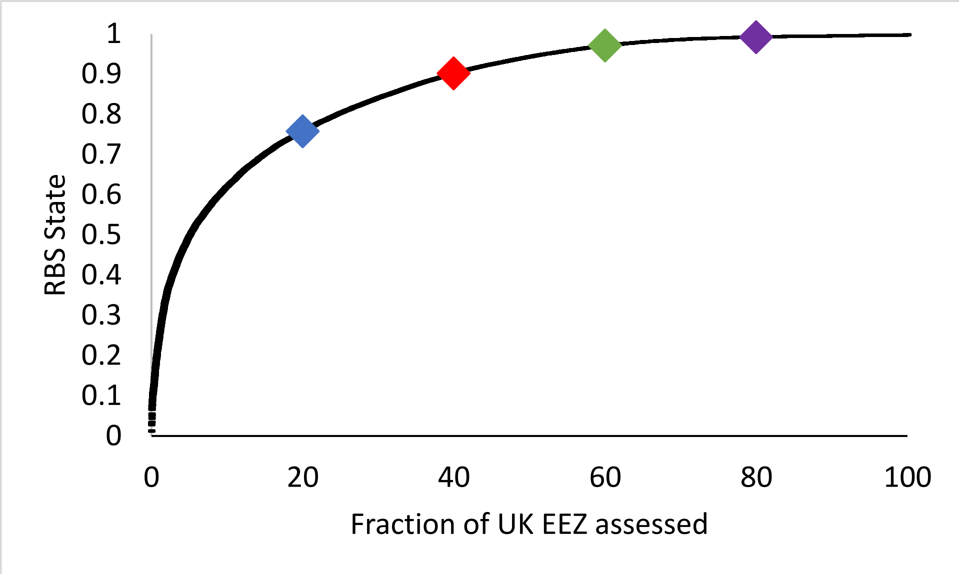

Figure 17. *Relative Benthic Status (RBS) against the cumulative fractional proportion of the UK EEZ bargrid study area. Blue diamond shows, 20% of the study area has an RBS output of <0.76. The red diamond shows, 40% of the study area is <0.90. The green diamond shows, 60% is <0.97, and the purple diamond shows that 80% of the study area is <0.99. A state of 1 is unimpacted and 0 is none of the originally community remains.*

The RBS output is summarized by main EUNIS habitat types in **Figure 17** and **Annex Figure 18.** Estimated Relative Benthic Status (RBS) output per EUNIS habitat type classification across the UK EEZ. <Null> values unclassified habitat types (see **Annex Annex Table 6**). Low values of RBS indicate higher impact on benthic community.

. Main EUNIS habitats were classified following the approach summarised in **Annex Table 6** and overlayed with the RBS output layer. EUNIS habitat type was selected for each c-square based on the largest habitat overlap within a c-square. Analysis of RBS output per habitat type shows that A5.3 (Sublittoral mud) is most affected by MBCG, with an average RBS output of 0.71. 47% of the extent of A5.3 is equal to or falls below the average RBS of 0.71, whereas 4.5% of this habitat has a RBS < 0.2, indicating that highest impact from bottom fishing in these areas. A6 (Deep-sea) habitat, also displays a low community state (average RBS output = 0.79), with 34% of the habitat having an RBS value equal to or lower than 0.79. A5.3 and A6 also have the highest average SAR values, 3.58 and 2.89, respectively. The largest habitat types assessed in terms of area, A5.1 (sublittoral coarse sediment) and A5.2 (sublittoral sand), have RBS an average RBS output of 0.91 and 0.88, respectively.

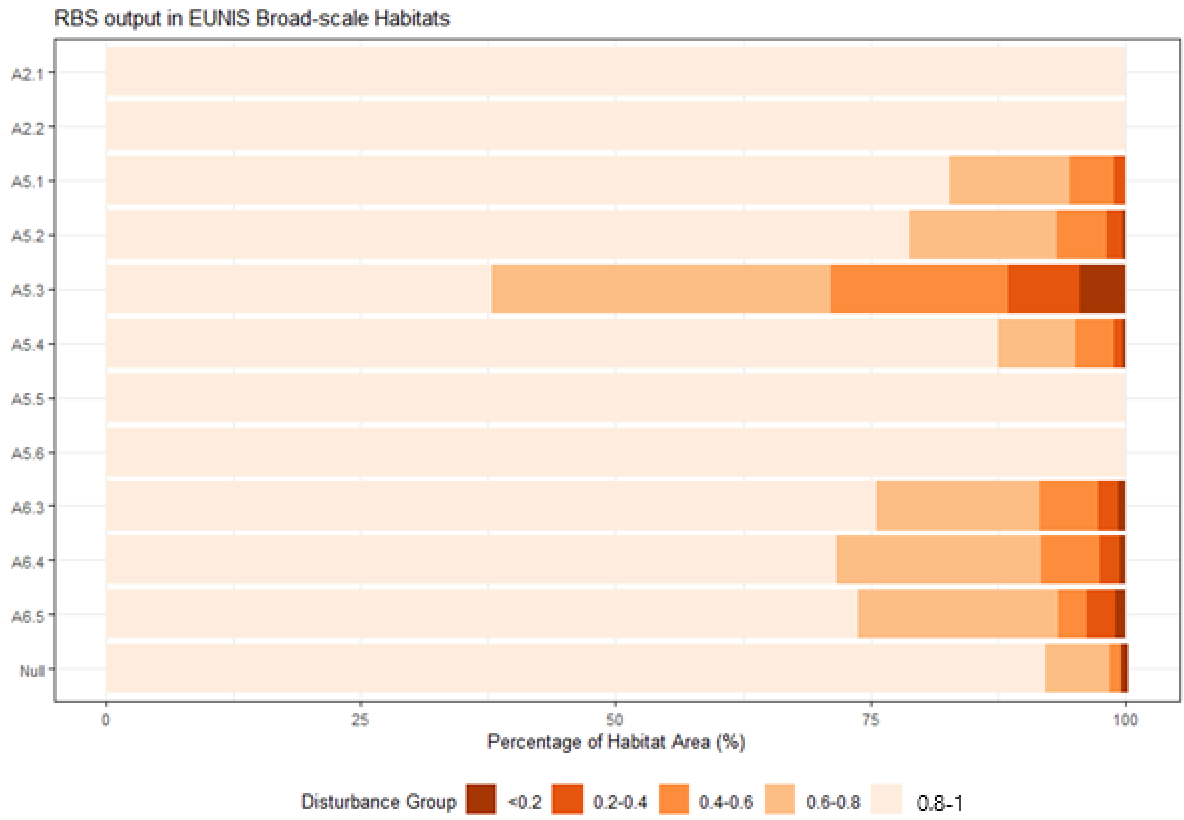

Figure 18. *Estimated Relative Benthic Status (RBS) output per [EUNIS] habitat type classification across the UK EEZ. <Null> values unclassified habitat types (see **Annex Annex Table 6**). Low values of RBS indicate higher impact on benthic community.*

The development and application RBS is relatively new (Pitcher et al., 2017), and there have not yet been enough studies to make meaningful comparisons across the entire UK EEZ. Any future work could build on the HWU biomass database collated and make use of more accurate supporting quantitative datasets.

Caveats on assessment of benthic habitat condition

The fishing pressure layers used in this study, were supplied by ICES which calculated SAR using VMS data submitted by EU member countries and was the best data available for fishing pressure. VMS data from Portugal, Norway and Iceland were not included in the assessment as the data did not pass ICES quality assurance checks or was not submitted. Additionally, VMS data for vessels < 12 m in length were not available at the time of assessment. Therefore, inshore areas, or areas where vessels below 12 m in length operate may be poorly represented, effecting the validity of both the BH3 and RBS output on finer coastal scales. Furthermore, assessments using a gridded approach assumed a homogenous distribution of pressure across an individual grid cell, which may not reflect real life where fishing is aggregated, targeting discrete areas of productive grounds. Therefore, the true spatial distribution of pressure within a grid cell may be overestimated in instances where bottom trawling or extraction activity was confined to discrete portions of a grid cell. However, in contrast to assessments of fishing pressure at c-square resolution (0.05 x 0.05 decimal degrees), assessments of aggregate extraction were undertaken using a much finer-scale grid resolution (50 m x 50 m grids), improving the spatial accuracy of pressure mapping and, therefore, disturbance calculations for this activity.

The method used in RBS assessment for assigning habitat types per c-square puts emphasis on the most distributed habitat, underrepresented habitats in terms of known distribution were omitted from the RBS analysis. This could include the most vulnerable habitats to MBCG. As the evidence base progresses, the best available predictions should be incorporated, and these analyses updated.

Conclusions

Despite the apprent differences in methodology, ultimately, both BH3 and RBS indicators identified A5.3 (Sublittoral mud) as being the habitat most disturbed by fishing (BH3) and the habitat that experienced the largest species community change (RBS). Deep sea sediments were mostly undirsturbed by fishing activity. However, there were areas in which fishing caused high disturbance to highly sensitive deep-sea habitats (particularly for A6 and A6.3&.4 EUNIS codes) (BH3), resulting in one of the strongest community change observed (RBS). Disturbance from mobile bottom-contacting gears also occured at various levels in all listed Threatened and/or Declining Habitats (BH3). The extent of disturbance caused by aggregate extraction activities is limited in the UK EEZ but when present, the levels of disturbance were moderate to high.

Author Contributions

Sciberras, M. and Vina-Herbon, C. developed the task workplan. Sciberras, M. had overall coordination of the task delivery. Marra, S. coordinated the work for the BH3 section. Marra, S., Matear, L., Woodcock, K.A., Duncombe-Smith, S.W., Smith, A.P., Vina-Herbon, C. contributed to the data analysis and report writing of the BH3 section. Sciberras, M., Morris, K., Kaiser, M. contributed to the data analysis and report writing of the RBS section.

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Annex

Annex Table 1. *EUNIS Broadscale and mosaic habitat total area and percentage of habitat area in the following disturbance groups from bottom-contacting fishing gear in the 2009 to 2020 BH3 assessment: 'Zero' = disturbance category 0; 'Low' = disturbance categories 1-4; 'Moderate' = disturbance* categories 5-7; 'High' = disturbance categories 8 and 9; 'Unassessed Disturbance' = area where fishing pressure was present but disturbance could not be assessed due to i) no habitat data, or ii) no sensitivity assessments for underlying habitat.* Total habitat areas are derived from the processed BH3 fisheries assessment layers and may not represent the entire habitat area in the UK EEZ.

EUNIS Broadscale and mosaic habitats	Total Area (km²)*	Percentage of Habitat Type for each disturbance group (%)				
		Zero	Low	Moderate	High	Unassessed Disturbance
A1.1&A1.2&A3.2	<0.01	100				
A1.4&A5.5	<0.01	100				
A3	53.28	45		42	14	
A3.1	1161.41	57	34	3	6	
A3.1&A4.1	3.16	32	68			
A3.1&A4.1&A4.2	10.96			100		
A3.1&A4.2	0.52	70		30		
A3.1&A5.1	<0.01		100			
A3.1&A5.4	1.42	87		13		
A3.2	816.31	46	20	24	10	
A3.2&A4.1&A4.2	8.31	63	4	34		
A3.2&A4.2	78.59	12		54	34	
A3.2&A5	4.07	19		81		
A3.2&A5.4	1.45	62		38		
A3.3	426.43	48	30	8	14	
A3.7	0.09	99	<1			
A3.7&A4.1&A5.1	54.89		97	3		
A4	6.99	35		48	17	
A4.1	7232.66	39	46	3	12	
A4.1&A3.1	11.23	54	46			
A4.1&A4.2	307.88	39		52	9	
A4.1&A4.2&A4.3	0.55	13	73		14	
A4.1&A4.2&A5.1&A5.2	326.38		57	11	32	
A4.1&A5.1	51.43	21	79			
A4.1&A5.4	12.48	47	<1	53		
A4.1&A5.6	0.91	100				
A4.2	5194.06	16	12	34	18	19
A4.2&A5	50.05	20		80		
A4.2&A5.1	16.55	14		86		
A4.2&A5.4	1.08	14		86		
A4.3	1667.53	11	19	12	<1	58

EUNIS Broadscale and mosaic habitats	Total Area (km^2)*	Percentage of Habitat Type for each disturbance group (%)				
		Zero	Low	Moderate	High	Unassessed Disturbance
A4.7	0.06	19	<1	11	69	
A5	5924.80	77		20	3	
A5.1	153804.06	8	83	9	<1	<1
A5.1&A5.2	263.73	1	27	72		
A5.1&A5.4	1992.22	8		58	34	
A5.2	238054.94	8	33	58	1	<1
A5.2&A5.3	3.08	11	89			
A5.2&A5.4	2.23	100				
A5.3	83163.12	3	11	3	83	
A5.3&A5.4	<0.01	100				
A5.4	18334.59	12	54	19	16	
A5.5	185.57	50	12	37	1	<1
A5.6	856.27	30	26	32	13	
A5.7	1.00	100				
A6	17160.79	31		26	43	
A6.1	1430.97	57		3	<1	39
A6.2	27386.69	62	<1	25	14	<1
A6.3	1543.46	56		22	22	
A6.3&A6.4	21708.04	26		26	48	
A6.5	130109.30	83		10	7	
A6.6	20.44	51		49		
No EUNIS Data	11238.42	52	<1	<1		48

Annex Table 2. *The total area and percentage of each OSPAR Threatened and / or Declining Habitat's area under each of the following disturbance groups from bottom-contacting fishing gear in the 2009 to 2020 BH3a assessment: 'Zero' = disturbance category 0; 'Low' = disturbance categories 1-4; 'Moderate' = disturbance* categories 5-7; 'High' = disturbance categories 8 and 9.

OSPAR Threatened and/or Declining habitat	Total Area (km^2)	Percentage of Habitat Type for each disturbance group (%)			
		Zero	Low	Moderate	High
Coral gardens	4.99	61		39	
Intertidal mudflats	3392.33	68	23	8	
Intertidal *Mytilus edulis* beds on mixed and sandy sediments	177.71	48	36	16	
Littoral chalk communities	34.17	61	17		22
Lophelia pertusa reefs	82.88	37		62	1
Maerl beds	224.94	36		56	8
Modiolus modiolus horse mussel beds	199.98	79	21	1	0

OSPAR Threatened and/or Declining habitat	Total Area (km^2)	Percentage of Habitat Type for each disturbance group (%)			
		Zero	Low	Moderate	High
Sabellaria spinulosa reefs	3370.71	26	57	6	11
Seamounts	23112.08	46		50	4
Sea-pen and burrowing megafauna communities	33018.97	3	8	2	87

***Annex Table 3.** The total area of EUNIS broad-scale habitats and percentage of this area in each of the following disturbance groups derived from marine aggregate extraction pressure between the years 2009 to 2020: 'Zero' = disturbance category 0; 'Low' = disturbance categorise 1-4; 'Moderate' = disturbance categories 5-7; 'High' = disturbance categories 8 and 9; 'Unassessed Disturbance' = areas where extraction activity occurred but there was an absence of habitat and / or sensitivity data.*

EUNIS Broad-scale Habitat	Total Habitat Area (km^2)	Zero	Low	Moderate	High	Unassessed Disturbance
A4.1	7221	99.966%	<0.001%	0.013%	0.021%	0%
A4.2	5196	99.979%	0%	0.012%	0.009%	0%
A5	5922	99.989%	0%	0.004%	0.006%	0%
A5.1	153794	99.874%	0.056%	0.01%	0.06%	0%
A5.2	238008	99.98%	0.01%	0.003%	0.007%	0%
A5.3	83454	100%	<0.001%	<0.001%	<0.001%	0%
A5.4	18338	99.751%	0.088%	0.059%	0.102%	0%
A5.6	853	98.208%	0.002%	0.761%	1.029%	0%
No EUNIS Data	11139	99.981%	0%	0%	0%	0.019%

***Annex Table 4.** Generalised Liner Model (GLM) selection process used in the RBS analysis to predict longevity using habitat conditions for the total community. The model AIC scores are presented. Model 15 was used for further analysis.*

Model number	Model parameters	AIC
mod1	**Full model** Cumb ~ ll + depth + SAR + mud + sand + gravel + depth:ll + gravel:ll + SAR:ll + (1| ID) + (1| sampling device)	5950.152
mod2	**Tests if (1| gear) is required in random part of model** Cumb ~ ll + depth + SAR + mud + sand + gravel + depth:ll + gravel:ll + SAR:ll + (1| ID)	7528.904
mod3	**Tests if (1| ID) is required in random part of model** Cumb ~ ll + depth + SAR + mud + sand + gravel + depth:ll + gravel:ll + SAR:ll + (1| sampling device)	6454.786
Mod4	**Tests if SAR:ll is required in random part of model** Cumb ~ ll + depth + SAR + mud + sand + gravel + depth:ll + gravel:ll + (1| ID) + (1| sampling device)	5950.105
Mod5	**Tests if gravel:ll is required in random part of model** Cumb ~ ll + depth + SAR + mud + sand + gravel + depth:ll + SAR:ll + (1| ID) + (1| sampling device)	5950.172

Mod6	**Tests if depth:ll is required in random part of model** Cumb ~ ll + depth + SAR + mud + sand + gravel + gravel:ll + SAR:ll + (1| ID) + (1| sampling device)	5947.845
Mod7	**Tests if interaction is required in random part of model** Cumb ~ ll + depth + SAR + mud + sand + gravel + (1| ID) + (1| sampling device)	5946.749
Mod8	**Tests if gravel is needed** Cumb ~ ll + depth + SAR + mud + sand + (1| ID) + (1| sampling device)	5943.124
Mod9	**Tests if sand is needed** Cumb ~ ll + depth + SAR + mud + gravel + (1| ID) + (1| sampling device)	5943.38
mod10	**Tests if mud is needed** Cumb ~ ll + depth + SAR + sand + gravel + (1| ID) + (1| sampling device)	5943.162
mod11	**Tests if SAR is needed** Cumb ~ ll + depth + mud + sand + gravel + (1| ID) + (1| sampling device)	5945.556
mod12	**Tests if depth is needed** Cumb ~ ll + SAR + mud + sand + gravel + (1| ID) + (1| sampling device)	5943.473
mod13	**Tests if ll is needed** Cumb ~ depth + SAR + mud + sand + gravel + (1| ID) + (1| sampling device)	7824.922
mod14	**Tests if sand is needed** Cumb ~ ll + depth + SAR + mud + (1| ID) + (1| sampling device)	5944.08
mod15	**Tests if mud is needed** Cumb ~ ll + depth + SAR + sand + (1| ID) + (1| sampling device)	5941.179
mod16	**Tests if SAR is needed** Cumb ~ ll + depth + mud + sand + (1| ID) + (1| sampling device)	6715.105
Mod17	**Tests if depth is needed** Cumb ~ ll + SAR + mud + sand + (1| ID) + (1| sampling device)	5941.896
Mod18	**Tests if ll is needed** Cumb ~ depth + SAR + mud + sand + (1| ID) + (1| sampling device)	7823.87
Mod19	**Tests if sand is needed** Cumb ~ ll + depth + SAR + (1| ID) + (1| sampling device)	5943.075
Mod20	**Tests if SAR is needed** Cumb ~ ll + depth + sand + (1| ID) + (1| sampling device)	5942.205
Mod21	**Tests if depth is needed** Cumb ~ ll + SAR + sand + (1| ID) + (1| sampling device)	5939.953
Mod22	**Tests if ll is needed** Cumb ~ SAR + sand + (1| ID) + (1| sampling device)	7822.186

Annex Table 5. *Estimated Relative Benthic Status (RBS) output per EUNIS habitat type classification across the UK EEZ. <Null> values unclassified habitat types. Low values of RBS indicate higher impact on benthic community. Habitat extent not assessed indicates the size of the area for each habitat that could not be included in the RBS calculation because of lack of fauna and/or environmental data.*

EUNIS habitat type	**Habitat extent (km^2)**	**Habitat extent assessed (km^2)**	**Mean SAR**	**Mean RBS output**	**RBS output per fractional area of assessed habitat extent**				
					<0.2	0.21 - 0.40	0.41- 0.6	0.61- 0.8	0.81-1
<Null>	1126.45	423030.20	0.80	0.95	0.72%	0.00%	1.09%	6.29%	92.19%
A2.1	50.49	9.63	0.03	0.98	0.00%	0.00%	0.00%	0.00%	100.00%
A2.2	1513.50	85083.46	0.13	0.97	0.00%	0.00%	0.00%	0.00%	100.00%
A5.1	157943.04	483723.61	1.83	0.91	0.03%	1.07%	4.38%	11.80%	82.71%
A5.2	258134.97	484374.26	1.55	0.88	0.25%	1.53%	4.94%	14.47%	78.81%

A5.3	63894.20	450977.21	3.71	0.71	4.48%	7.10%	17.28%	33.27%	37.87%
A5.4	18370.62	462000.56	1.60	0.93	0.29%	0.88%	3.69%	7.61%	87.54%
A5.5	178.81	56079.65	0.00	1.00	0.00%	0.00%	0.00%	0.00%	100.00%
A5.6	499.89	29591.80	0.45	0.98	0.00%	0.00%	0.00%	0.00%	100.00%
A6.3	28929.59	484480.70	1.95	0.84	0.74%	2.00%	5.72%	15.99%	75.55%
A6.4	4509.54	484004.23	1.78	0.83	0.55%	1.96%	5.84%	19.92%	71.72%
A6.5	121048.96	482279.48	1.90	0.87	0.93%	2.91%	2.70%	19.65%	73.80%

Annex Table 6. *EUNIS habitat classification approach. Original habitat map classifications (EUNIS level 3 (L3) were analyses for spatial extent and combined into larger groupings. Where habitats have a combined classification (e.g., A3.1 + A4.1) the leading classification is the dominant habitat type.*

Text description	**Combined classification**	**Habitat map classifications (EUNIS_L3)**
Littoral coarse sediment	A2.1	A2.1
		A2.1 + A2.4
		A2.1 + A2.2
Littoral sand and muddy sand	A2.2	A2.2
		A2.2 + A2.3
Littoral mud	A2.3	A2.3
		A2.3 + A2.4
		A2.3 + A2.5
Littoral mixed sediment	A2.4	A2
		A2.4
		A2.4 + A2.8
Sublittoral coarse sediment	A5.1	A5.1
		A5.1 + A5.2
		A5.1 + A5.4
Sublittoral sand	A5.2	A5.2
		A5.2 + A5.3
		A5.2 + A5.4
Sublittoral mud	A5.3	A5.3
Sublittoral mixed sediments	A5.4	A5
		A5.4
		A5.4 + A5.1
Sublittoral sediments characterized by submerged rooted plants	A5.5	A5.5
Deep-sea sand	A6.3	A6.3
Deep-sea mixed substrata	A6.4	A6
		A6.2
		A6.4
Deep-sea mud	A6.5	A6.5
No habitat type assigned (A, <Null> or Na) OR RBS assessment cannot be applied to these habitat types	<Null>	Na
		<Null>
		A
		A1
		A1.1

		A1.1 + A1.2
		A1.1 + A1.3
		A1.1 + A1.4
		A1.2
		A1.2 + A1.3
		A1.2 + A1.4
		A1.2 + A2.4
		A1.3
		A1.4
		A1.4 + A5.5
		A2.5
		A2.6
		A2.6 + A5.5
		A2.7
		A2.8
		A3
		A3 + A1
		A3.1
		A3.1 + A4.1
		A3.1 + A4.2
		A3.1 + A5.1
		A3.1 + A5.4
		A3.2
		A3.2 + A4.1
		A3.2 + A4.2
		A3.2 + A5.4
		A3.3
		A4
		A4.1
		A4.1 + A4.2
		A4.1 + A4.7
		A4.1 + A5.1
		A4.1 + A5.4
		A4.1 + A5.6
		A4.2
		A4.2 + A5.1
		A4.2 + A5.4
		A4.3
		A4.7
		A6.6
		B
		B1.2
		B1.3
		B2.1
		B2.3
		B2.4
		B3

		B3.1
		C3.44