Task 2. Habitat assessment

Monkfish

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Executive Summary

This report aims to provide information for the improvement of the sustainability of the Celtic Sea and western English Channel monkfish Fisheries Impovement Project associated fleet in terms of its impact on habitats. The analyses and results presented here refer to the impact of fishing vessels that participate in the Celtic Sea and western English Channel monkfish Fisheries Impovement project (FIP). Trips were selected based on gear type used: beam trawl, otter trawls, Danish seines, and pair seines. Other vessels that might target the same species in these areas were not considered.

The fleet effort was derived from vessel monitoring system (VMS) and logbook data. Effort distribution estimates refer to the unit of assessment in terms of area and the gears used by the the vessels that belong to specified producers’ organisations participating in the FIP. Habitat maps were derived from publicly available databases (EUSeaMap, OSPAR and ICES) and used to identify Vulnerable Marine Ecosystems (VMEs), threatened and declining habitats, and common substrates. These cover the Celtic Sea and western English Channel (ICES sub regions 27.7.b, 27.7.c-h, 27.7.j, 27.7.k). The extent of the habitats was clipped to the extent of the unit of assessment as indicated by the FIP participants.

Two indicators were used to quantify the impact of the FIP vessels on different types of habitats: i) A simple indicator based on the area overlap between fishing effort and habitats to show the percentage of a type of habitat that overlaps with fishing effort. This indicator doesn’t account for the intensity of the fishing effort or for the recovery rate of the habitat, two parameters that have proven challenging to estimate. Ii) A more complex indicator, Relative Benthic Status (RBS), was developed to account for the intensity of the fishing effort or for the recovery rate of the habitat. This indicator however has uncertainties mainly due to some of the parameters necessary for its calculation. It is worth noting that both indicators combined can provide a complete assessment of the impact of the FIP vessels on different habitats.

For the first indicator, effort maps were overlayed on habitat distributions and the overlapping area was calculated. The percentage of the habitat that overlaps with fishing effort was calculated. These values can be used to identify cases where a big proportion of a certain habitat is impacted by the fishery, per gear and how fishing effort is distributed in terms of habitats exploited. This indicator is useful for habitats with low recoverability where even low fishing effort could impact the habitat beyond recovery. The analysis focused mainly on these habitats but we also present calculations of this indicator for commonly encountered habitats.

We also used the rate of change in benthic biomass over time to calculate the Relative Benthic Status (RBS), a quantitative indicator of the risk of depletion for benthic habitats, i.e. the rate of change in abundance of benthic biomass in time due to fishing. RBS has been developed for fisheries impact assessments on habitats and it combines information on (i) the time it takes a habitat to recover after a disturbance and (ii) the magnitude of the disturbance, in this case the magnitude of the impact of the gear and the frequency that the gear is used in an area. RBS is the percentage of the habitat that will be able to recover within a year after the disturbance. RBS was not calculated for vulnerable habitats such as reefs or sea pens because estimates on the recovery of these habitats per fishing gear are not available and these parameters are necessary for the calculation of RBS. This analysis was restricted to commonly encountered habitats.

The fishing effort of the monkfish FIP fleet overlaps with soft corals at around 10% (VMEs), and with Littoral chalk communities at a percentage that can reach 18% (OSPAR threatened and declining habitats) in the Celtic Sea and western English Channel. These habitats have low recoverability and based on MSC standards, the overlap should be lower than 20%. Findings therefore show that the percentage overlap is lower than the MSC threshold for both VMEs and OSPAR threatened and declining habitats. RBS values for the monkfish FIP vessels are lower than 80% for coarse sediments impacted by beam trawls (TBB), otter trawls (OTB) and otter twin trawls (OTT). In these cases, the impact of the vessels on commonly encountered habitats does not meet MSC standards.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | average overlap | maximum overlap | average RBS | minimum RBS |
| **commonly encountered habitats** | | | | |
| Coarse sediment | 1.39 | 2.53 | 79.35 | 58.07 |
| Fine mud | 0.24 | 0.39 | 99.97 | 99.95 |
| Mixed sediment | 0.56 | 1.26 | 93.07 | 85.54 |
| Rock or other hard substrata | 0.41 | 0.74 | 97.54 | 93.06 |
| Sand | 1.51 | 2.48 | 94.29 | 87.21 |
| Sandy mud to muddy sand | 0.31 | 0.87 | 93.89 | 86.38 |
| Seabed | 3.44 | 7.86 | 99.92 | 99.88 |
| **VMEs** | | | | |
| Sea-pen | 3.33 | 3.33 |  |  |
| Soft coral | 10.94 | 12.44 |  |  |
| **Protected and Declining Habitats** | | | | |
| Intertidal mudflats | 0.96 | 2.20 |  |  |
| Intertidal Mytilus edulis beds on mixed and sandy sediments | 0.12 | 0.32 |  |  |
| Littoral chalk communities | 7.66 | 18.29 |  |  |
| Maerl beds | 0.64 | 1.09 |  |  |
| Modiolus modiolus horse mussel beds | 0.77 | 0.77 |  |  |
| Sabellaria spinulosa reefs | 2.42 | 6.25 |  |  |
| Sea-pen and burrowing megafauna communities | 1.44 | 3.58 |  |  |
| Zostera beds | 2.43 | 3.77 |  |  |

TABLE Average and maximum values of percent overlap per habitat type. Average and minimum RBS values for commonly encountered habitats.

Caveats of this analysis relate to two main sources of uncertainty: (i) VMS and logbooks are not available for all trips and/or all FIP vessels and (ii) recovery and depletion rates are not specific to the fleet and its area of operation. The results therefore could be characterised by a possible bias that relates to lack of information on the distribution of effort for the proportion of the fisheries with vessel length <12m, as these vessels are not obliged to report logbooks or use VMS. Errors of fishing set identification are also probable (but not quantifiable) due to the long interval between consecutive VMS pings (2hours) when fishing sets might take less than 2 hours. The RBS calculations involve the use of recovery and depletion rates that are not specific to the area, thus the results could be uncertain.

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# Background

According to MSC assessment criteria, interactions with common and vulnerable marine habitats (VME) need to be identified and quantified. To inform improvements for the monkfish targeting fishery in the Celtic Sea and western English Channel, we assessed the impact of the vessels that participate in the Fisheries Improvement Project (FIP) on benthic habitats. We overlaid maps of fishing effort to maps of habitats, including VMEs, threatened and declining habitats and assessed the overlap in terms of area. Because VMEs, threatened and declining habitats have very slow recovery rates, their recovery can take decades. According to the MSC criteria, 80% of the distribution should remain intact, or in other words less than 20% of their distribution should be fished. For common habitats we followed an assessment approach proposed by Pitcher et al.( 2016) and Szostek et al. (2017) that relates to the distribution and intensity of the fishery and the gears it uses to the ‘sensitivity’ of the habitat i.e. the capacity of the habitat to recover. The assessment approach has been proposed based on the needs of MSC assessments.

# Methodology

## Effort Distribution

Effort distribution was based on VMS and logbook data from vessels that relate to the unit of assessment as this was defined in terms of vessels, gears and area of operation. The list of vessels and related RSS numbers was provided by MSC. Logbook trip records were selected based on the following criteria:

1. The vessel was included in the list of unique Registry of Shipping and Seamen (RSS) number provided by MSC. These included 193 RSS numbers from FIP associated vessels that target monkfish in the Celtic Sea and western English channel and participate in the Fisheries Improvement Project. Not all of these vessels related to the RSS numbers have logbook and VMS data (Table 1) due to reporting obligations requiring only vessels > 15m until 2013; and for vessels > 12m from 2013 onwards (Figure 1) to have these onboard.

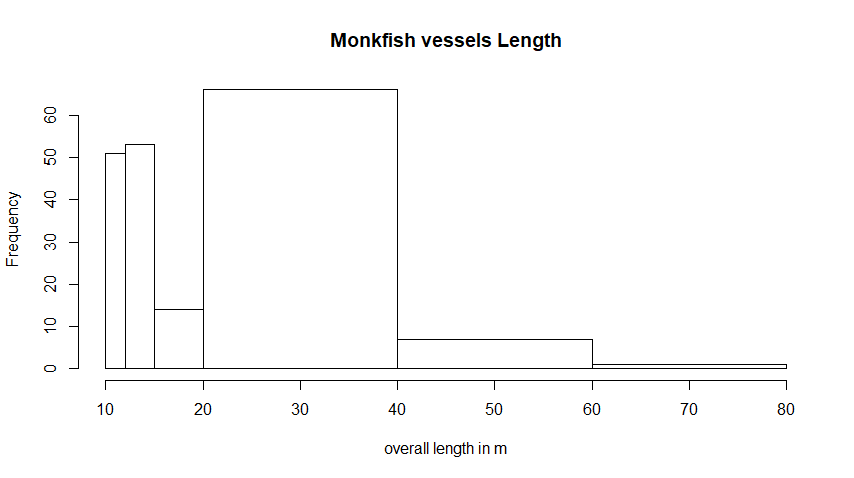


Figure 1 Histogram of the overall vessel length for the given list of vessels. The first two bars show vessels 10m-12m and vessels 12m-15m. We should note here that possibly some of the vessels do not target monkfish. However, for the vessels < 12m (or 15m before 2012-2013), we cannot know what they are targeting, which is a source of uncertainty.

Table 1 Number of unique RSS numbers for which logbook records were available

|  |  |
| --- | --- |
| year | # RSS |
| 2012 | 154 |
| 2013 | 159 |
| 2014 | 168 |
| 2015 | 173 |
| 2016 | 177 |

1. The fisheries take place in areas (ICES rectangle) indicated by MSC as the unit of assessment. For the North Sea, the ICES rectangles indicated were 27.7.b, 27.7.c, 27.7.d, 27.7.e, 27.7.f, 27.7.g, 27.7.h, 27.7.j, 27.7.k; Logbook trips that record these rectangles as their fishing area were selected.

Table 2 Number of RSS numbers that report fishing in the indicated areas with the indicated gears.

|  |  |
| --- | --- |
| year | # RSS |
| 2012 | 86 |
| 2013 | 90 |
| 2014 | 95 |
| 2015 | 102 |
| 2016 | 98 |

1. Trips that report the following fishing gear usage were selected: beam trawls TBB, otter trawls – bottom OTB, pair trawls bottom PTB, otter twin trawls OTT, Danish seines SDN, and pair seines. The code of pair seines was not found in the logbooks database, possibly because their trips are classified under pair trawls PTB due to the similarity between the two gears. Table 2 shows the number of vessels (RSS) in the list that reports fishing in the indicated areas with the above-mentioned gears.
2. To select trips where the species in question are targeted, we analysed logbook data for the specified vessels/area/gear combinations. The percentage of the catch of monkfish in the total catch of the trip was calculated. Then we found the percentage of the species in the total trip catch that should be selected so that the trips would account for at least 95% of the total species catch on a given year. Finally, the trips with species catch proportion equal or greater than the percentage calculated above were selected. Table 3 and 4 shows the species catch proportions used to select trips.

Table 3 cut-off points in terms of species catch ratio per trip for the selection of trips that will account for at least 95% of the annual species catch.

|  |  |
| --- | --- |
| Year | Monkfish catch % |
| 2012 | 6% |
| 2013 | 7% |
| 2014 | 9% |
| 2015 | 7% |
| 2016 | 7% |

Table 4 Number of trips analysed per year per fishery.

|  |  |
| --- | --- |
| year | # of trips |
| 2012 | 4366 |
| 2013 | 3655 |
| 2014 | 4113 |
| 2015 | 4787 |
| 2016 | 5152 |

Selected logbook records were merged with VMS records based on temporal and spatial information and fishing operations were identified based on speed patterns. The effort was estimated based on the duration of fishing operations (hours) and the data were aggregated to a 0.05 x 0.05 decimal degrees (DD) grid. The analysis followed the workflow adopted by ICES for the analysis of VMS and logbook data, and the algorithms developed by Gerritsen & Lordan (2011) and Hintzen et al. (2012). The fishing speed patterns used were derived from experts’ opinion (mainly through interviews with fisheries observers).

Annual maps of the distribution of the monkfish FIP associated fleet for the period 2012-2016 were produced. The data were aggregated per gear.

## Habitat Distribution

Habitat data were derived from three sources:

1. The EMODnet broad-scale seabed habitat map for Europe 2016 (EUSeaMap 2016) which is a predictive habitat map which covers the seabed of a large area of European waters ([www.emodnet-seabedhabitats.eu](http://www.emodnet-seabedhabitats.eu)). Substrate layers were derived from this dataset (Cameron & Askew 2011). This source indicates common habitats.
2. The EMODnet OSPAR Threatened and/or Declining Habitats 2015, which is ‘a compilation of OSPAR habitat data for the northeast Atlantic, compiled on behalf of the OSPAR Commission’ (https://odims.ospar.org/). The list of threatened and/or declining species and habitats in the North-East Atlantic was established by OSPAR as part of its commitment to assess species and habitats that need to be protected. The most comprehensive dataset is in the form of points. For the purposes of this analysis, a buffer of 0.05 DD was built around the points and the resulting areas were dissolved into polygons. The dataset includes Vulnerable Marine Ecosystems (VMEs) but also other protected, declining and priority habitats with high depletion and low recovery rates.
3. The ICES Vulnerable Marine Ecosystems (VMEs), (and organisms considered to be indicators of VMEs) across the North Atlantic was derived from the ICES data portal (http://vme.ices.dk/download.aspx). The ICES VME dataset gives the location of “Vulnerable Marine Ecosystems (VMEs), (and organisms considered to be indicators of VMEs) across the North Atlantic has been set up by the Joint ICES/NAFO Working Group on Deep-water Ecology (WGDEC).  Criteria used to select habitats and indicators for inclusion in the database were those described in the FAO International Guidelines for the Management of Deep-sea Fisheries in the High Seas (FAO, 2009)” (ICES, n.d.). The dataset records both VME habitats that have been verified and VME indicators. This was the only dataset publicly available. All VME indicators for all years were downloaded. The data are provided in the form of lines. Hence, for the purposes of this analysis, a 0.05 DD buffer was built around the lines and dissolved into polygons.

All three datasets were clipped to the extent of the indicated area of operation namely the ICES rectangles 27.7.b, 27.7.c, 27.7.d, 27.7.e, 27.7.f, 27.7.g, 27.7.h, 27.7.j, 27.7.k(Fig 2). Figure 3 is a map of the VMEs in the area of interest, as these are depicted in the ICES VMEs database.

A close up of a map

Description automatically generated

Figure 2 The extent of the habitat layers was clipped to the extent of the area that was indicated by the client as the area of operation of the FIP fleet, namely ICES rectangles 27.7.b, 27.7.c, 27.7.d, 27.7.e, 27.7.f, 27.7.g, 27.7.h, 27.7.j, 27.7.k. The figure shows the EMODnet broad-scale seabed habitat map clipped at the extent of ICES rectangles 27.7.b, 27.7.c, 27.7.d, 27.7.e, 27.7.f, 27.7.g, 27.7.h, 27.7.j, 27.7.k.

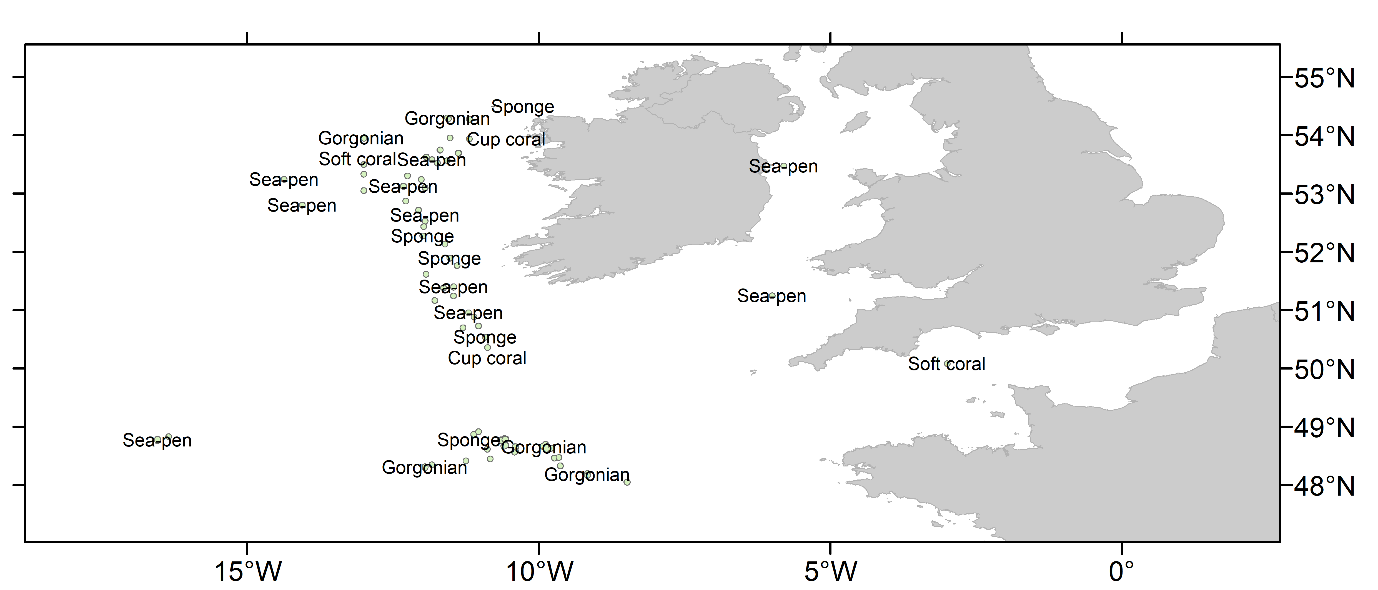


Figure 3 VMEs mapped based on the ICES Vulnerable Marine Ecosystems (VMEs) dataset.

## Indicator 1: Habitat – Fisheries Overlap

A GIS algorithm was developed to calculate the overlap between the distribution of the fishery and each of the habitats. The algorithm was applied to pairings of the fishery distribution and each of the habitat layers. It involved: (i) intersect between the grid of the distribution of the fishery for a certain year and the polygon of the habitat, and (ii) calculation of the common area per habitat type or substrate.

The total area of the distribution of each fishery was calculated based on the available VMS data for the FIP fleet, as described in section 2.1. To calculate the area that is occupied by a certain habitat: (i) the habitat dataset was clipped based on the areas indicated by the client and related ICES rectangles, and (ii) the total area was calculated (per habitat type or substrate in the case of the EUSeaMap 2016 data).

Indicator 1 is the proportion of habitat area that overlaps with fishing effort (*Ph*)

Ph = Ofh / Ah (equation 1)

Where *Ofh* is the overlap area between fishing effort and habitat *Ah*

VMEs and threatened habitats have low recovery rates (> 5 years) and high depletion rates. For these habitats low overlap (< 20%) would be in line with MSC criteria.

## Indicator 2: Relative Benthic Status

To evaluate the impact of the fisheries on common benthic habitats, we used the approach described in Pitcher et al. (2016) and Szostek et al. (2017) and calculated the Relative Benthic Status (RBS), a quantitative indicator of the risk of depletion for benthic habitats, i.e. the rate of change in abundance in time. According to Pitcher et al. (2016) estimating RBS requires only maps of fishing intensity and habitat type and parameters for impact and recovery rates, which might be taken from meta-analyses. Equation 2 describes this relationship.

(equation 2),

where F is trawling frequency, d is the depletion rate of biota caused by each trawl pass (expressed as a proportion), and r is the rate of increase of biota interpreted here as the recovery rate.

The swept area was calculated based on the methodology developed by Gerritsen et al.( 2013) for VMS data. Depletion of biota (*d*) and recovery rates ( *r*) were derived from literature, namely two meta-analyses of experimental studies. Pitcher et al. (2016) provide values of depletion and recovery for different types of habitats (Table 5) and Hiddink et al. (2017) for different types of trawling gears (Table 6).

Table 5 Values of depletion and recovery for different types of habitats after (Pitcher et al. 2016).

|  |  |  |
| --- | --- | --- |
| Habitat | R (recovery rate) | D (depletion rate) |
| Mud | 5.5 | 0.27 |
| Muddy Sand | 4.1 | 0.41 |
| Sand | 12.5 | 0.37 |
| Gravel | 2.2 | 0.48 |

Table 6 Values of depletion and recovery for otter and beam trawls after (Hiddink et al. 2017). The median recovery rate reported by the authors was 0.82.

|  |  |  |
| --- | --- | --- |
| Gear | R (recovery rate) | D (depletion rate) |
| Otter trawls (OT) | 1.05 | 0.16 |
| Beam trawls (BT) | 4.49 | 0.25 |

For the analysis, we used the average values of recovery and depletion for each combination of habitat and gear; e.g. if an otter bottom trawl (*d* = 0.16) impacts coarse sediments (*d* = 0.48) then the average *d* = 0.32 was used for the calculations. EUSeamap habitats have more classes than the ones reported by Pitcher et al. (2016). We used recovery and depletion values for those habitats that resembled the Pitcher et al. (2016) habitat classification the best. Annex 1 gives the values of recovery and depletion rates for each common habitat type in the EUSeamap habitats. Similarly, Annex 2 gives the values of recovery and depletion rates for each gear used by the FIP associated fleet when it targets monkfish.

RBS is an indicator of the status of a benthic habitat given the fishing effort of the fleet for a certain period. RBS = 0 indicates total depletion of a habitat due to fishing effort, while an RBS = 100% refers to the un-trawled state of the habitat. As such RBS > 80% can be considered to comply with the MSC criterion 2.4.1.

# Results

## Data: Effort and Habitat Distribution

A total of 177 RSS numbers related to FIP associated vessels had logbook records in the period 2012-2016. As already stated, some of the vessels (depending on their length) had no logbook records as they are not obliged to carry VMS and use logbooks. The match between logbook records and VMS records i.e. logbook records that could be linked to VMS records ranged from 51% (2012) to 71% (2016). Indicatively, in 2015, from the 99 RSS numbers selected in the logbook data, 73 had related VMS records (74%), from the 4787 trips. 3042 (64%) of these could be linked to VMS records (Table 7). Table 8 shows calculations of the mismatch between VMS data (pings) and logbooks. Figure 3 shows the distribution of the FIP fleet.

Table 7 Calculations of the mismatch between logbook records and VMS data. Logbook records do not perfectly match with VMS data due to errors in VMS data, low temporal resolution of the VMS data and subsequent misidentifications of fishing sets or because vessels below a certain length, which decreases through the years) are not obliged to have VMS.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| year | variable | logbooks | matched | % matching |
| 2012 | RSS numbers | 83 | 42 | 50.6 |
| 2012 | trips | 4366 | 1339 | 30.7 |
| 2012 | revenue | 1492145 | 831047 | 55.7 |
| 2012 | catch | 11549234 | 8768732 | 75.9 |
| 2013 | vessels | 84 | 48 | 57.1 |
| 2013 | trips | 3655 | 1517 | 41.5 |
| 2013 | revenue | 627051 | 310426 | 49.5 |
| 2013 | catch | 10846128 | 8931060 | 82.3 |
| 2014 | vessels | 91 | 60 | 65.9 |
| 2014 | trips | 4113 | 2055 | 50 |
| 2014 | revenue | 668117 | 464530 | 69.5 |
| 2014 | catch | 10463624 | 8759274 | 83.7 |
| 2015 | vessels | 99 | 73 | 73.7 |
| 2015 | trips | 4787 | 3042 | 63.5 |
| 2015 | revenue | 692492 | 551126 | 79.6 |
| 2015 | catch | 12206454 | 11196202 | 91.7 |
| 2016 | vessels | 97 | 72 | 74.2 |
| 2016 | trips | 5152 | 3360 | 65.2 |
| 2016 | revenue | 910363 | 701717 | 77.1 |
| 2016 | catch | 12427823 | 11442755 | 92.1 |

Table 8 Calculations of the mismatch between VMS data (pings) and logbooks. VMS data do not perfectly match with logbook records.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| year |  | number of VMS pings | % of linked pings | % of remaining pings |
| 2012 | Total | 78826 |  |  |
| 2012 | Not able to link | 184 | 99.77 | 0.23 |
| 2013 | Total | 86138 |  |  |
| 2013 | Not able to link | 233 | 99.73 | 0.27 |
| 2014 | Total | 93356 |  |  |
| 2014 | Not able to link | 268 | 99.71 | 0.29 |
| 2015 | Total | 119740 |  |  |
| 2015 | Not able to link | 688 | 99.43 | 0.57 |
| 2016 | Total | 135749 |  |  |
| 2016 | Not able to link | 652 | 99.52 | 0.48 |

A close up of a map

Description automatically generated

Figure 4 Fishing effort distribution of the FIP vessels per gear for 2016.

## Indicator 1: Habitat – Fisheries Overlap

Indicator 1 shows the percentage of habitat area that overlaps with fishing effort per gear. The analysis of the VMEs ICES database shows that although fishing effort overlaps with sea pens and soft corals, the percentage overlap is lower than 20% (Table 9), thus complying with the MSC requirements.

The above-mentioned results are confirmed by the analysis of the OSPAR dataset that includes VMEs and other vulnerable habitats with low recovery rates. The percentage overlap is lower than 20%. Table 10 shows all cases where the percentage of the habitat that overlaps with effort exceeds 5%.

Table 9 Indicator 1: proportion of VMEs overlapping with fishing effort per gear and year.

|  |  |  |  |
| --- | --- | --- | --- |
| VME Indicators | year | gear | Indicator 1: Ph |
| Sea-pen | 2014 | OTB | 3.33 |
| Soft coral | 2015 | TBB | 12.44 |
| Soft coral | 2014 | TBB | 12.44 |
| Soft coral | 2016 | OTT | 3.60 |
| Soft coral | 2016 | OTB | 10.76 |
| Soft coral | 2013 | TBB | 12.44 |
| Soft coral | 2012 | TBB | 12.44 |
| Soft coral | 2016 | TBB | 12.44 |

Table 10 Indicator 1: proportion of threatened and declining habitats, based on Ospar database, overlapping with fishing effort per gear and year. The values presented are > 5%.

|  |  |  |  |
| --- | --- | --- | --- |
| Ospar habitat type | year | gear | Indicator 1: Ph |
| Littoral chalk communities | 2016 | TBB | 18.29 |
| Littoral chalk communities | 2015 | TBB | 13.56 |
| Littoral chalk communities | 2013 | TBB | 9.40 |
| Littoral chalk communities | 2015 | OTB | 9.17 |
| Littoral chalk communities | 2014 | TBB | 8.58 |
| Littoral chalk communities | 2016 | OTB | 6.36 |
| *Sabellaria spinulosa* reefs | 2012 | TBB | 6.25 |

Indicator 1 was also calculated for common substrates. Table 11 shows all values greater than 5%. All values are lower than 20%. Recovery rate and depletion rate values for common habitats, denoted here by the different substrates are variable (see methodology for specific values) and they are not considered as vulnerable as the habitats found in the ICES VMEs database and the OSPAR database. This indicator does not account for recovery and depletion, so for these habitats RBS was also calculated. Ph can be useful along with depletion and recovery rates to find the reason for low RBS values and ways to mitigate impact on habitats.

Table 11 Indicator 1: proportion of substrate overlapping with fishing effort per gear and year. The values presented are > 5%.

|  |  |  |  |
| --- | --- | --- | --- |
| Substrate | year | gear | Indicator 1: Ph |
| Seabed | 2014 | TBB | 7.86 |
| Seabed | 2012 | TBB | 7.83 |
| Seabed | 2016 | TBB | 7.82 |
| Seabed | 2013 | TBB | 7.76 |
| Seabed | 2015 | TBB | 7.71 |

All area calculations per habitat, gear and year can be found in the Annexe table 5.

## Indicator 2: Relative Benthic Status

Table 12 shows the average RBS values per year per substrate per gear. These values show that on average the status of common habitats relative to un-trawled habitats is > 80%. Annex 6 shows all RBS values per year, gear and common habitat (substrate). The monkfish FIP associated fleet is characterised by RBS values lower than 80% for coarse sediments, which indicates that coarse sediments cannot recover to their 80% un-trawled status. It should be noted that the real status of the habitat depends on all fleets that use towed gears and that the current analysis accounts only for the FIP vessels.

Table 12 Average RBS values per year, per substrate and gear. All values are above 80%.

|  |  |
| --- | --- |
| year | RBS |
| 2012 | 91.23 |
| 2013 | 94.73 |
| 2014 | 93.03 |
| 2015 | 86.90 |
| 2016 | 89.43 |
| substrate |  |
| Coarse sediment | 79.35 |
| Fine mud | 99.98 |
| Mixed sediment | 93.07 |
| Rock or other hard substrata | 97.54 |
| Sand | 94.29 |
| Sandy mud to muddy sand | 93.89 |
| Seabed | 99.92 |
| gear |  |
| OTB | 94.29 |
| OTT | 94.66 |
| PTB | 99.96 |
| TBB | 88.65 |

Table 13 The lowest RBS value for monkfish FIP associated vessels. The values presented here are < 80%. All other combinations of gear – substrate are presented in Annexe Table 6.

|  |  |  |  |
| --- | --- | --- | --- |
| habitat | gear | RBS | Year |
| Coarse sediment | TBB | 2016 | 58.07 |
| Coarse sediment | TBB | 2012 | 59.89 |
| Coarse sediment | TBB | 2015 | 59.92 |
| Coarse sediment | TBB | 2013 | 63.35 |
| Coarse sediment | TBB | 2014 | 64.34 |
| Coarse sediment | OTB | 2016 | 71.50 |
| Coarse sediment | OTB | 2015 | 74.02 |
| Coarse sediment | OTT | 2015 | 74.30 |

# Discussion

## Quantifying the impact of the FIP fleet

The habitat-fisheries overlap analysis shows that the overlap between three different types of VMEs and fishing effort was less than 20%. The same analysis based on OSPAR data show that less than 20% of the area occupied by threatened and declining habitats overlapped with the fishing activity of the FIP fleet. Littoral chalk communities show overlap values ~10%. According to OSPAR, a percentage of each habitat type that OSPAR characterises as threatened and declining habitats falls under disturbance categories 5-9, which means that after disturbance, recovery will not take place in less than a decade.

RBS values for the monkfish FIP fleet are lower than 80% for coarse sediments and beam trawlers and otter trawlers. Based on the RBS values for common habitats, and beam or otter trawlers, in the absence of fishing, the coarse sediments could not recover to 80% compared to an undisturbed habitat.

## Caveats

Three sources of uncertainty could affect the reliability of the results of the habitat assessment and relate to (i) the fishing effort data, (ii) the habitat distribution data, and (iii) the depletion and recovery rates. Vessels below 15m until 2013; and for vessels below 12m from 2013 onwards do not have logbooks or VMS data. As a result, we do not account for the fishing effort of approximately 50 RSS numbers of related vessels and could underestimate the fishing effort and the magnitude of fishing disturbance. There is uncertainty on the distribution of VMEs and other threatened and declining habitats. The data are derived mainly from surveys and only a percentage of the fishery operation area is covered by surveys. Also, because surveys have been conducted after fishing activities had commenced the un-trawled, ‘unimpacted’ level of the habitat is largely unknown. Finally, depletion and recovery rates come from meta-analyses and are not specific to all the gears used and all the different types of impacted habitats. Both rates greatly affect RBS values.

The analysis presented here focuses on the impact of a part of the fishing effort in the Celtic Sea and western English Channel relating to the monkfish FIP associated fleet. The values presented refer to the recovery of habitats if the given fleet were the only one operating in the area. We are not assessing the cumulative impact of all fisheries in the area hence the estimated values will underestimate the total disturbance of the benthic ecosystems and overestimate the relative benthic status.

## Suggestions for Improvements

Regarding the quality of information used in this analysis, improved estimates of impact could be achieved if all vessels, including those below the obligatory length of 12m, reported logbooks and carried a location monitoring device. This could be either VMS or AIS (Automatic Identification Systems). The latter could provide better temporal resolution of location data that would further decrease the uncertainty around fishing set identification. Reliable information could come from habitat models that predict the distribution of such features but are not yet available. Knowledge of recovery and depletion values for the specific fisheries and the habitats they disturb could affect the results of the assessment. Experimental studies in the areas of interest could provide more reliable values for these parameters.

Fishers can be informed of the locations of vulnerable habitats to avoid them and contribute to the improvement of current habitat distribution maps by reporting encountering vulnerable habitats in areas that the current maps do not cover. Based on RBS values (< 80%) coarse sediments should be avoided; compared to other commonly encountered habitats, coarse sediments have high depletion rates and low recovery rates.

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Annex 1

|  |  |  |
| --- | --- | --- |
| substrate | Depletion rate | Recovery rate |
| Coarse and mixed sediment | 0.48 | 2.2 |
| Coarse sediment | 0.48 | 2.2 |
| Cymodocea beds | 0.48 | 2.2 |
| *Cymodocea nodosa* meadows | 0.48 | 2.2 |
| Dead mattes of *Posidonia oceanica* | 0.48 | 2.2 |
| Fine mud | 0.27 | 5.5 |
| Mixed sediment | 0.41 | 4.1 |
| Mud to muddy sand | 0.27 | 5.5 |
| Muddy Sand | 0.41 | 12.5 |
| *Posidonia oceanica* meadows | 0.48 | 2.2 |
| Rock or other hard substrata | 0.48 | 2.2 |
| Sand | 0.37 | 12.5 |
| Sandy mud | 0.41 | 4.1 |
| Sandy mud to muddy sand | 0.41 | 4.1 |
| Seabed | 0.41 | 4.1 |
| Unknown | 0.41 | 4.1 |

Annex Table 1 Depletion and recovery rates per substrate. The table shows the values used as input for the RBS calculation.

|  |  |  |
| --- | --- | --- |
| gear | Depletion rate | Recovery rate |
| OTB | 0.16 | 1.05 |
| OTT | 0.25 | 1.05 |
| PTB | 0.16 | 0.82 |
| SDN | 0.16 | 0.82 |
| TBB | 0.25 | 4.49 |

Annex Table 2 Depletion and recovery rates per gear. The table shows the values used as input for the RBS calculation.

Annexe Table 3 Indicator 1: proportion of VMEs overlapping with fishing effort per gear and year.

| VME Indicators | year | gear | Indicator 1: Ph |
| --- | --- | --- | --- |
| Sea-pen | 2014 | OTB | 3.33 |
| Soft coral | 2015 | TBB | 12.44 |
| Soft coral | 2014 | TBB | 12.44 |
| Soft coral | 2016 | OTT | 3.60 |
| Soft coral | 2016 | OTB | 10.76 |
| Soft coral | 2013 | TBB | 12.44 |
| Soft coral | 2012 | TBB | 12.44 |
| Soft coral | 2016 | TBB | 12.44 |

Annexe Table 4 Indicator 1: proportion of threatened and declining habitats, based on Ospar database, overlapping with fishing effort per gear and year. Values > 15% are highlighted.

| Habitat Type | year | gear | Indicator 1: Ph |
| --- | --- | --- | --- |
| Littoral chalk communities | 2016 | TBB | 18.29 |
| Littoral chalk communities | 2015 | TBB | 13.56 |
| Littoral chalk communities | 2013 | TBB | 9.40 |
| Littoral chalk communities | 2015 | OTB | 9.17 |
| Littoral chalk communities | 2014 | TBB | 8.58 |
| Littoral chalk communities | 2016 | OTB | 6.36 |
| Sabellaria spinulosa reefs | 2012 | TBB | 6.25 |
| Sabellaria spinulosa reefs | 2016 | TBB | 4.55 |
| Littoral chalk communities | 2014 | OTB | 3.87 |
| Zostera beds | 2015 | OTB | 3.77 |
| Zostera beds | 2014 | TBB | 3.68 |
| Sabellaria spinulosa reefs | 2015 | OTB | 3.67 |
| Zostera beds | 2015 | TBB | 3.64 |
| Sea-pen and burrowing megafauna communities | 2016 | OTB | 3.58 |
| Sea-pen and burrowing megafauna communities | 2014 | OTB | 3.28 |
| Zostera beds | 2013 | TBB | 3.15 |
| Zostera beds | 2016 | TBB | 3.13 |
| Sabellaria spinulosa reefs | 2016 | OTB | 2.87 |
| Littoral chalk communities | 2012 | TBB | 2.67 |
| Sabellaria spinulosa reefs | 2013 | TBB | 2.62 |
| Sea-pen and burrowing megafauna communities | 2016 | TBB | 2.46 |
| Littoral chalk communities | 2015 | OTT | 2.36 |
| Sabellaria spinulosa reefs | 2014 | TBB | 2.34 |
| Littoral chalk communities | 2016 | OTT | 2.29 |
| Zostera beds | 2016 | OTB | 2.22 |
| Zostera beds | 2014 | OTB | 2.21 |
| Intertidal mudflats | 2015 | OTB | 2.20 |
| Zostera beds | 2012 | TBB | 2.16 |
| Zostera beds | 2016 | OTT | 1.89 |
| Sea-pen and burrowing megafauna communities | 2012 | TBB | 1.79 |
| Sabellaria spinulosa reefs | 2014 | OTB | 1.75 |
| Zostera beds | 2015 | OTT | 1.62 |
| Intertidal mudflats | 2016 | TBB | 1.51 |
| Intertidal mudflats | 2015 | TBB | 1.46 |
| Intertidal mudflats | 2014 | TBB | 1.15 |
| Maerl beds | 2016 | OTB | 1.09 |
| Sabellaria spinulosa reefs | 2015 | TBB | 1.09 |
| Maerl beds | 2014 | OTB | 1.05 |
| Sea-pen and burrowing megafauna communities | 2015 | TBB | 1.04 |
| Intertidal mudflats | 2016 | OTB | 1.02 |
| Sea-pen and burrowing megafauna communities | 2014 | TBB | 0.99 |
| Intertidal mudflats | 2015 | OTT | 0.96 |
| Maerl beds | 2015 | OTB | 0.94 |
| Maerl beds | 2012 | TBB | 0.90 |
| Sea-pen and burrowing megafauna communities | 2013 | TBB | 0.89 |
| Intertidal mudflats | 2014 | OTB | 0.88 |
| Zostera beds | 2012 | OTB | 0.88 |
| Maerl beds | 2016 | TBB | 0.85 |
| Intertidal mudflats | 2013 | TBB | 0.83 |
| Zostera beds | 2014 | OTT | 0.81 |
| Modiolus modiolus horse mussel beds | 2014 | OTB | 0.77 |
| Sabellaria spinulosa reefs | 2015 | OTT | 0.75 |
| Sabellaria spinulosa reefs | 2016 | OTT | 0.75 |
| Maerl beds | 2015 | OTT | 0.62 |
| Maerl beds | 2015 | TBB | 0.49 |
| Maerl beds | 2016 | OTT | 0.46 |
| Maerl beds | 2014 | TBB | 0.45 |
| Intertidal Mytilus edulis beds on mixed and sandy sediments | 2016 | OTB | 0.32 |
| Intertidal mudflats | 2016 | OTT | 0.27 |
| Intertidal mudflats | 2012 | TBB | 0.24 |
| Sea-pen and burrowing megafauna communities | 2015 | OTB | 0.22 |
| Maerl beds | 2013 | TBB | 0.12 |
| Intertidal Mytilus edulis beds on mixed and sandy sediments | 2015 | TBB | 0.12 |
| Intertidal Mytilus edulis beds on mixed and sandy sediments | 2016 | TBB | 0.12 |
| Sea-pen and burrowing megafauna communities | 2015 | OTT | 0.10 |
| Maerl beds | 2014 | OTT | 0.06 |
| Intertidal mudflats | 2014 | OTT | 0.03 |
| Sea-pen and burrowing megafauna communities | 2016 | OTT | 0.03 |
| Intertidal Mytilus edulis beds on mixed and sandy sediments | 2013 | TBB | 0.02 |
| Intertidal Mytilus edulis beds on mixed and sandy sediments | 2014 | TBB | 0.02 |
| Sabellaria spinulosa reefs | 2012 | OTB | 0.00 |

Annexe Table 5 Indicator 1: proportion of common benthic habitats, indicated as types of substrate, overlapping with fishing effort per gear and year. All values are lower than 20%.

|  |  |  |  |
| --- | --- | --- | --- |
| Substrate | year | gear | Indicator 1: Ph |
| Seabed | 2014 | TBB | 7.86 |
| Seabed | 2012 | TBB | 7.83 |
| Seabed | 2016 | TBB | 7.82 |
| Seabed | 2013 | TBB | 7.76 |
| Seabed | 2015 | TBB | 7.71 |
| Coarse sediment | 2014 | TBB | 2.53 |
| Sand | 2012 | TBB | 2.48 |
| Seabed | 2016 | OTB | 2.33 |
| Coarse sediment | 2012 | TBB | 2.33 |
| Seabed | 2015 | OTB | 2.20 |
| Coarse sediment | 2016 | TBB | 1.98 |
| Coarse sediment | 2013 | TBB | 1.83 |
| Sand | 2015 | TBB | 1.82 |
| Sand | 2016 | TBB | 1.78 |
| Sand | 2014 | TBB | 1.72 |
| Seabed | 2014 | OTB | 1.60 |
| Coarse sediment | 2015 | TBB | 1.51 |
| Sand | 2015 | OTB | 1.45 |
| Sand | 2016 | OTB | 1.39 |
| Sand | 2013 | TBB | 1.34 |
| Mixed sediment | 2012 | TBB | 1.26 |
| Seabed | 2016 | OTT | 1.22 |
| Sandy mud to muddy sand | 2016 | OTB | 0.87 |
| Mixed sediment | 2016 | TBB | 0.81 |
| Mixed sediment | 2015 | OTB | 0.79 |
| Seabed | 2015 | OTT | 0.78 |
| Sandy mud to muddy sand | 2014 | OTB | 0.78 |
| Rock or other hard substrata | 2012 | TBB | 0.74 |
| Mixed sediment | 2015 | TBB | 0.63 |
| Seabed | 2012 | OTB | 0.51 |
| Rock or other hard substrata | 2016 | OTB | 0.51 |
| Rock or other hard substrata | 2015 | TBB | 0.50 |
| Seabed | 2014 | OTT | 0.50 |
| Rock or other hard substrata | 2013 | TBB | 0.48 |
| Coarse sediment | 2016 | OTB | 0.46 |
| Mixed sediment | 2013 | TBB | 0.44 |
| Fine mud | 2014 | OTB | 0.39 |
| Rock or other hard substrata | 2015 | OTB | 0.38 |
| Rock or other hard substrata | 2016 | TBB | 0.35 |
| Sandy mud to muddy sand | 2016 | TBB | 0.34 |
| Coarse sediment | 2015 | OTB | 0.31 |
| Sandy mud to muddy sand | 2012 | TBB | 0.28 |
| Mixed sediment | 2016 | OTB | 0.27 |
| Rock or other hard substrata | 2014 | TBB | 0.21 |
| Fine mud | 2016 | OTB | 0.20 |
| Coarse sediment | 2014 | OTB | 0.19 |
| Mixed sediment | 2014 | OTB | 0.14 |
| Fine mud | 2015 | OTB | 0.12 |
| Mixed sediment | 2014 | TBB | 0.12 |
| Sandy mud to muddy sand | 2014 | TBB | 0.10 |
| Rock or other hard substrata | 2014 | OTB | 0.08 |
| Sand | 2014 | OTB | 0.08 |
| Sandy mud to muddy sand | 2015 | TBB | 0.07 |
| Seabed | 2013 | OTB | 0.06 |
| Sandy mud to muddy sand | 2013 | TBB | 0.03 |
| Seabed | 2016 | PTB | 0.02 |
| Sandy mud to muddy sand | 2015 | OTB | 0.01 |

|  |  |  |  |
| --- | --- | --- | --- |
| Habitat type | year | gear | RBS |
| Coarse sediment | 2016 | TBB | 58.07 |
| Coarse sediment | 2012 | TBB | 59.89 |
| Coarse sediment | 2015 | TBB | 59.92 |
| Coarse sediment | 2013 | TBB | 63.35 |
| Coarse sediment | 2014 | TBB | 64.34 |
| Coarse sediment | 2016 | OTB | 71.50 |
| Coarse sediment | 2015 | OTB | 74.02 |
| Coarse sediment | 2015 | OTT | 74.30 |
| Coarse sediment | 2016 | OTT | 83.03 |
| Coarse sediment | 2014 | OTB | 83.04 |
| Mixed sediment | 2015 | OTT | 85.54 |
| Sandy mud to muddy sand | 2015 | TBB | 86.38 |
| Mixed sediment | 2012 | TBB | 86.60 |
| Mixed sediment | 2016 | OTT | 87.15 |
| Sand | 2016 | OTB | 87.21 |
| Sandy mud to muddy sand | 2015 | OTB | 87.31 |
| Mixed sediment | 2013 | TBB | 87.60 |
| Sandy mud to muddy sand | 2015 | OTT | 88.54 |
| Sand | 2015 | OTB | 88.79 |
| Sandy mud to muddy sand | 2016 | OTT | 89.22 |
| Mixed sediment | 2016 | TBB | 89.48 |
| Mixed sediment | 2014 | TBB | 90.20 |
| Sand | 2016 | TBB | 90.25 |
| Sandy mud to muddy sand | 2016 | TBB | 90.57 |
| Mixed sediment | 2015 | TBB | 90.70 |
| Sand | 2015 | TBB | 91.06 |
| Sand | 2014 | OTB | 91.88 |
| Sand | 2012 | TBB | 92.62 |
| Sand | 2014 | TBB | 92.71 |
| Sandy mud to muddy sand | 2013 | TBB | 92.93 |
| Sand | 2013 | TBB | 92.98 |
| Rock or other hard substrata | 2014 | OTB | 93.06 |
| Mixed sediment | 2016 | OTB | 93.08 |
| Sand | 2016 | OTT | 93.32 |
| Sandy mud to muddy sand | 2014 | TBB | 93.41 |
| Sand | 2015 | OTT | 93.69 |
| Sandy mud to muddy sand | 2016 | OTB | 93.72 |
| Sandy mud to muddy sand | 2012 | TBB | 93.82 |
| Rock or other hard substrata | 2012 | TBB | 94.84 |
| Rock or other hard substrata | 2015 | OTB | 95.49 |
| Mixed sediment | 2015 | OTB | 95.60 |
| Rock or other hard substrata | 2016 | TBB | 95.75 |
| Rock or other hard substrata | 2015 | TBB | 95.83 |
| Rock or other hard substrata | 2016 | OTB | 96.44 |
| Rock or other hard substrata | 2013 | TBB | 96.69 |
| Mixed sediment | 2014 | OTB | 97.28 |
| Rock or other hard substrata | 2014 | TBB | 98.53 |
| Sandy mud to muddy sand | 2014 | OTB | 98.76 |
| Coarse sediment | 2014 | OTT | 99.50 |
| Coarse sediment | 2012 | OTB | 99.56 |
| Rock or other hard substrata | 2016 | OTT | 99.61 |
| Rock or other hard substrata | 2015 | OTT | 99.71 |
| Rock or other hard substrata | 2012 | OTB | 99.71 |
| Coarse sediment | 2013 | OTB | 99.74 |
| Mixed sediment | 2014 | OTT | 99.84 |
| Seabed | 2014 | TBB | 99.88 |
| Seabed | 2015 | TBB | 99.88 |
| Sandy mud to muddy sand | 2014 | OTT | 99.89 |
| Sand | 2014 | OTT | 99.90 |
| Mixed sediment | 2012 | OTB | 99.92 |
| Rock or other hard substrata | 2014 | OTT | 99.93 |
| Coarse sediment | 2016 | PTB | 99.93 |
| Seabed | 2012 | TBB | 99.93 |
| Seabed | 2016 | TBB | 99.93 |
| Sandy mud to muddy sand | 2012 | OTB | 99.94 |
| Sand | 2012 | OTB | 99.95 |
| Fine mud | 2014 | OTB | 99.95 |
| Seabed | 2013 | TBB | 99.97 |
| Fine mud | 2016 | OTB | 99.97 |
| Rock or other hard substrata | 2013 | OTB | 99.99 |
| Sand | 2016 | PTB | 99.99 |
| Sand | 2013 | OTB | 100.00 |
| Mixed sediment | 2013 | OTB | 100.00 |
| Sandy mud to muddy sand | 2013 | OTB | 100.00 |
| Coarse sediment | 2013 | OTT | 100.00 |
| Mixed sediment | 2013 | OTT | 100.00 |
| Rock or other hard substrata | 2013 | OTT | 100.00 |
| Sand | 2013 | OTT | 100.00 |
| Sandy mud to muddy sand | 2013 | OTT | 100.00 |
| Fine mud | 2013 | TBB | 100.00 |

Annexe Table 6 Monkfish FIP associated fleet RBS estimates per habitat, gear and year. Values <80% are highlighted.

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