Marine Management Organisation

Mapping important areas for the UK and non-UK 12-metre and over fishing fleets – phase 3 (MMO 1467)

Technical Report

...ambitious for our seas and coasts

MMO1467: Mapping important areas for the UK and non-UK 12-metre and over fishing fleets – phase 3
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Contents

Non-technical Summary

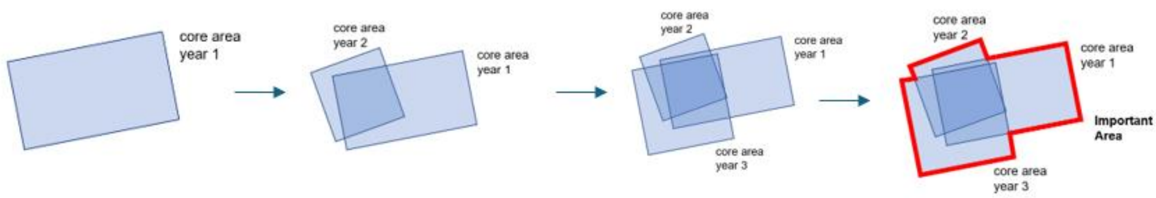
In 2022, following the publication of the British Energy Security Strategy, the Department for Environment, Food and Rural Affairs (Defra) commissioned the Marine Management Organisation (MMO) to model areas for future offshore wind and map important areas for current fisheries in English waters. The work in support of this commission created initial maps of current fishing activity for i) UK 12-metre and over, ii) the UK under 12-metre and iii) the non-UK 12-metre and over fleets, for the period 2016-2021. Alongside these maps a technical report was produced which contained several recommendations for future work, and the maps were subsequently engaged on with the fisheries industry in the summer of 2023, leading to further recommendations for future improvements to the work.

This technical document relates to the continuation of the fisheries activity mapping work, with the aim to further develop understanding of the areas used by, and important to the fishing industry, and implement recommendations from the first round of mapping as well as subsequent engagement.

A range of fishing activity metrics (fishing effort (hours and kilowatt hours), weight, and value of landings) were used to describe the distribution and intensity of fishing activity, which was subsequently mapped across the study area consisting of English, Welsh and Northern Ireland marine areas.

Analysis indicated that while fishing activity was widespread throughout the study period, present in more than 80% of the study area, activity is concentrated and consists of smaller, intensively fished areas, and larger, infrequently fished margins. “Core areas” (defined as the footprint of the top 80% of cumulative fishing in each year) exhibited year to year variation in both size and location but with substantial overlap among years.

From core areas, “important” areas were developed and defined as those areas that identified as a core area in one or more years. Analysis then explored the location and size of important areas and how important areas differed among different gear and species groupings.



There was variation in how clearly important areas could be identified by gear and species, with certain groupings showing well defined important areas while other areas were more dispersed. Many important areas were transboundary spanning fishing administrations within the UK Exclusive Economic Zone (EEZ) or extending into neighbouring states' waters.

Analysis was also run to identify the areas of the sea from which most ports received landings, with up to 24 different ports landing fish from western Scotland and north east England. Examination of the areas where individual ports received landings from, further highlighted that while an area may not register as an important area at a national level, they may still be highly valuable at a local community level.

Different metrics for fishing activity identify similar important areas suggesting strong links between effort and landings-based metrics at the scale assessed. However important areas differed strongly among gear groupings, the UK 12-metre and over fleet and non-UK 12-metre and over fleet, and among target species.

Analysis was also run on gear groupings at a marine plan area scale for the north east marine plan area and south west marine plan area to investigate any significant differences in important areas on a regional versus a national scale. This analysis highlighted that important areas varied when looking at the national scale versus a more regional scale.

The 80% activity threshold identified in 2022 was also tested and was found to be, for the most part, appropriate with a degree of variation between different gears and species. However, the method used to test the threshold was also found to perform poorly where the overall spatial extent of the dataset being examined was small, and further refinement of the method will be required to improve confidence.

This report identifies important areas based on criteria and metrics applied, but areas are found to be sensitive to methodology (e.g., temporal and spatial scale, gear resolution). Selecting appropriate methods and criteria is ultimately a societal question related to a vision for fisheries, any objectives sought and what interventions are being considered.

Data remains a limitation, particularly the spatial scale at which it is available. Although not available for this project, data streams like inshore vessel monitoring system (iVMS), Under10 Catch App and reporting from non-UK vessels to the UK as an independent coastal state could improve data quality in the future.

Background and Purpose

Context

In 2022, following the publication of the British Energy Security Strategy, the Department for Environment, Food and Rural Affairs (Defra) commissioned the Marine Management Organisation (MMO) to model and map important areas for future offshore wind and current fisheries in English waters.

The scope for Defra's commission was set out in an overall specification document, agreed by the Marine Spatial Prioritisation Programme Board. The scope set out the high-level objectives, deliverables, and delivery method for the project. The high-level specification was then supplemented by a more detailed fisheries activity mapping specification, which laid out the proposed approach to mapping undertaken here and identified potential data sources and limitations. Defra have a copy of this specification, and it is available on request from MMO. Outputs of this commission were presented in the Fisheries Mapping Technical Report 2022, which is also available on request.

To validate the outputs a series of workshops were completed with stakeholders in May of 2023. Stakeholders included fishers, industry representatives and producer organisations, and decision-making authorities relevant to 12-metre and over vessels. The outputs were well received stakeholder feedback suggested further work to more accurately represent fishing activity in and around UK waters.

Suggested amendments ranged from improved consideration of locally important fishing areas, improvements to data for specific fleet segments such as non-UK over 12-metre and UK under 12-metre vessels, displacement, and consideration of importance for specific species. This current round of fisheries mapping addressed these suggestions where it is technically feasible to do so, and to include more recent data, with the outputs intended for use in strategic and spatial planning in UK waters.

Since the original commission other developments in fisheries activity mapping have progressed, including the completion of the Centre for Environment, Fisheries and Aquaculture Science's (Cefas) Fisheries Sensitivity Mapping and Displacement Model (FiSMaDiM) project[1]. This round of MMO's fisheries mapping will also address these developments and make comparisons to FisMaDiM.

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[1] Cefas (2025) FiSMaDiM (Fisheries Sensitivity Mapping and Displacement Modelling) project outputs available at Case Study - Cefas (Centre for Environment, Fisheries and Aquaculture Science) accessed 18/08/2025

This document sets out the context of the work completed, data used, methodology applied, and analytical outputs generated. It also includes MMO's interpretation of the results and any caveats and limitations associated with that interpretation. Based on progress of, and insights from the project, next steps are also suggested.

Aims and Objectives

The aims and objectives for this project, build on previous iterations of fisheries mapping and were:

1) Increase the time series of data used to include the most recent years of fisheries data to:
    a. Make use of the most recent available data from 2022 and 2023,
    b. Provide further insight into interannual variability in core areas,
    c. Assess how a longer time series influences important area size and how long a time series might need to be, and
    d. Improve understanding of inter-annual variability and their influence on important areas
2) Improve data confidence by rerunning 2022 analysis using improved GeoFISH data inputs
3) Apply the methodology for determining important areas for target fisheries species
4) Align analysed gear groupings with those used in the Fisheries Sensitivity Mapping and Displacement model (FiSMaDiM) for greater comparability
5) Explore areas of local importance through examination of catch locations against their ports of landing
6) Test the robustness of the assumptions made for the cut-off threshold for which an area is defined as a 'core area' for fishing
7) Adress several recommendations gathered during the 2023 engagement on the first phase of work

Definition of Areas of Important Fishing Activity Areas

The 2022 fisheries mapping project set out definitions for "fishing activity", "Core Areas", and "Areas Important for Fishing", these definitions have been maintained for this project and are as follows:

<ins>Fishing Activity</ins>: is defined by EU retained legislation, originally under the Control Regulation (EU 1224/2009) that fishing activity is "*searching for fish, shooting, setting, towing, hauling of a fishing gear, taking catch on board, transhipping,*

retaining on board, processing on board, transferring, caging, fattening and landing of fish and fisheries products"

Core Areas: *a subset of the total area fished in any one period (usually a year) where a significant proportion of shooting, setting, towing, or hauling of a fishing gear is conducted*. In this study, "*significant"* was defined and validated as the top 80% of cumulative activity in the year.

Area(s) Important for Fishing: "*area(s) that have disproportionate value in sustaining viable fisheries*". Practically here that is the sum of all the core areas in any one year across all years of study i.e., cumulative core area. This aggregation of core areas across years accounts for interannual variation and cyclic patterns in fisheries.

Core Areas can be generated for any subset of the fishing data, allowing for identification of the Core Areas for any given year, spatial extent, gear type or gear grouping, species, and port of landing. As a result, Areas Important for Fishing are dependent upon the context in which the Core Areas have been generated. For example, an area of the sea may not be defined as an Area Important for Fishing when examining core areas at a national scale, but may be an Area Important for Fishing when examining core areas at a regional scale or for a specific port.

Metrics for Describing Fishing Activity

Multiple metrics can be used to describe fishing activity and ascribe importance to reveal important patterns in the data for effective fisheries management. MMO (2014) provides a non-exhaustive list compiled by the three pillars of sustainability which has been expanded for this report;

- Economic (e.g., value of landings, volume of landings, level of fishing effort, Gross Value Added),
- Social (e.g., number of people employed, cultural significance, community dependency)
- Physical/biological/environmental (e.g., swept area, disturbance pressure, habitat or weather accessibility)

Different metrics may be appropriate for different fleet segments, different geographic areas or for different policy or management objectives or impact assessments. Combining different of metrics could be particularly useful in considering multiple overlapping benefits.

During the 2022 project the following metrics were agreed with Defra to define Areas Important for Fishing;

- Effort (kWh)
- Landings (tonnage)

- Landings (value)
- Effort (hrs) – precursor for employment
- Employment (person hrs/day)
- Sustainability

It was not possible to identify any environmental sustainability metric(s) that could be used to identify Areas Important for Fishing within the scope of previous phases. Attempts to undertake pressure-sensitivity mapping using the Natural England Spatial Sensitivity Tool were trialled, but this was not carried forward.

Economic sustainability is considered by examining the implications of important areas identified by other metrics. Further, employment was examined through scaling time-based fishing effort statistics (hours for the UK 12-metre and over and days for the UK under 12-metre segments) with estimates of vessel crew size to give person hours or person days. There was a poor match between the fleet segments used in the employment data and those that MMO can create with available data at this time.

Due to the lack of alignment between these datasets the sustainability and employment metrics have not been directly explored in this project.

Fleet Breakdowns for Describing Fishing Activity

While the primary focus of this project is on the UK 12-metre and over fleet, where data availability allowed analysis also considered the non-UK 12-metre and over fleet.

The UK 12-metre and over fleet and non-UK 12-metre and over fleet were each broken down by gear groups. Gear types were grouped to align with the gear groupings used in the FiSMaDiM project[2], allowing for greater compatibility and comparability between the two spatial fishery data products. The full breakdown of gear codes in each grouping are presented in **Table 1**.

Table 1. Provides the full breakdown of gear groupings by gear codes, as well as a Yes/No of which gear codes are present in the GeoFISH and Non-UK VMS Datasets.

[2] Muench, A., Mendo, T.; Ransijn, J.; Durbach, I. Gibson, T.; Swift, R., James, M: Fisheries Sensitivity Mapping and Displacement Modelling (FiSMaDiM) – Final project report. Report produced for The Crown Estate, OWEC funded project: FiSMaDiM, 35 pages. Doi: 10.14465/2024.OWEC.004,Available at Fisheries Sensitivity Mapping and Displacement Modelling (FiSMaDiM) Final project report

Gear Grouping	Gear Code	GeoFISH	Non-UK VMS
Demersal trawl	OT	Yes	Yes
	OTB	Yes	Yes
	OTT	Yes	Yes
	PTB	Yes	Yes
	TB	Yes	Yes
	TBB	Yes	Yes
	TBN	Yes	Yes
	TBS	No	Yes
	TX	No	Yes
Gillnets and entangling nets	GEN	No	Yes
	GN	Yes	Yes
	GNC	No	Yes
	GND	No	Yes
	GNS	Yes	Yes
	GTN	No	Yes
	GTR	Yes	Yes
Hooks and lines	HF	Yes	No
	LHP	No	Yes
	LL	Yes	Yes
	LLD	No	Yes
	LLS	Yes	Yes
	LTL	No	Yes
	LTL	No	Yes
	LX	No	Yes
Miscellaneous	LNB	No	Yes
	MIS	Yes	No
	RG	Yes	No
Pelagic trawl	OTM	Yes	Yes
	PTM	Yes	Yes
	TMS	No	Yes
Pots and traps	FIX	Yes	No
	FPO	Yes	Yes
Scallop dredge	DRB	Yes	Yes
	DRH	No	Yes
	DRM	No	Yes
	HMD	Yes	Yes
Seine nets	SDN	No	Yes
	SPR	No	Yes
	SSC	Yes	Yes
	SV	Yes	No
	SX	No	Yes
Surrounding nets	PS	Yes	Yes

Analysis was also undertaken without splitting the gear groups, representing the whole of each fleet.

The UK 12-metre and over fleet was also broken down using landings data to examine 11 key target species, as well as 'Others'. The target species are listed below in **Table 2.**

Table 2. Target species, their species codes and scientific names.

Species Name	Species Code	Scientific Name
Cod	COD	*Gadus morhua*
Edible crab	CRE	*Cancer pagurus*
Haddock	HAD	*Melanogrammus aeglefinus*
Hake	HKE	*Merluccius merluccius*
Herring	HER	*Clupea harengus*
Mackerel	MAC	*Scomber scombrus*
Monks or Anglers	ANF	*Lophiidae*
Nephrops	NEP	*Nephrops norvegicus*
Scallops	SCE	*Pecten maximus*
Sole	SOL	*Solea solea*
Whiting	WHG	*Merlangius merlangus*
Other	N/A	N/A

Landings data was also used to split the UK 12-metre and over fleet by the port of landing.

The UK under 12-metre fleet has not been included in this project as currently available data does not facilitate further detailed analysis beyond what was analysed in 2022. Due to the coarse resolution (ICES rectangles) of the UK under 12-metre data it is expected that increasing the time series will not show any significant changes in distribution of important fishing areas for that fleet segment.

Methods

The method to analyse the data provided and derive the maps largely follows that taken in Phase 2, which was developed in collaboration with the MMO Evidence team, MMO Marine Planning Team, and MMO Data, Technology, and Innovations team and with support from a technical working group. The work was summarised in presentations provided to fishers and others in workshops and detailed in the technical report produced as part of the first commission[3]. Full methodology from the Phase 2 report is also available in Annex 1.

[3] Modelling and/or mapping important areas for future offshore wind and for fisheries: Fisheries Mapping Technical Report

Data Source

UK 12-metre and over vessels

The UK 12-metre and over vessels fishing activity dataset draws on Vessel Monitoring System (VMS) data, linked to fisheries aggregated data extracted from the Cefas GeoFISH spatial database, with logbook data and fleet register data. GeoFISH is built on top of the integrated UK database (iFish2 that contains UK VMS and e-logbook data (data for England sourced from the MMO)).

GeoFISH was designed to meet the international reporting requirement set by ICES to map the aggregated distribution of fishing by different gear types across the OSPAR area, and to evaluate the spatial and temporal effects of fishing. GeoFISH combines VMS position with logbook data and automates the calculation of relevant fisheries metrics through spatial apportionment of landings to VMS data. It uses open-source technologies. Related code such as fishing speed or catch to ping allocation rules can be retrieved from the Cefas github repository (https://github.com/CefasRepRes/GeoFISH).

Section 4.2.1 (p.18) of MMO1384: Social and Economic Impact Assessments for Commercial Fisheries Management Decisions outlines the most appropriate data sources to use when assessing impacts on landings. It recommends that "for a proposal that applies to a specific spatial area smaller than an ICES rectangle, or overlapping several ICES rectangles, VMS data should be used where possible." On page 19, GeoFISH data is identified as the priority data source for such assessments.

GeoFISH, while robust for intended uses to support UK submission to ICES, is still developing as a system to manage UK fisheries geospatial data more generally. Due to current technical restrictions, it was not possible for the MMO to access GeoFISH directly within this project and therefore this project utilised an existing current geodatabase extracted from GeoFISH by Cefas partners reused with permission.

The geodatabase included UK 12-metre and over VMS linked activity data containing the following fishing activity metrics

- Effort (hrs/days)
- Effort (kWh)
- Landings Value (Tonnes)
- Landings Value (£GBP)

The GeoFISH data was provided as two separate data tables which offer different levels of disaggregation of fishing activity data, referred to as "table 1" and "table 2". Their characteristics are shown below (**Table 3**).

Table 3. The two tables of GeoFISH disaggregation of fishing activity data.

	Table 1	Table 2
Effort (kWh) metric	✓	✗
Effort (hours) metric	✓	✗
Value (£GBP) metric	✓	✓
Weight (tonnes) metric	✓	✓
Port of landing	✓	✓
Temporal extension 2016 – 2023	✓	✓
Temporal resolution: monthly	✓	✓
Geographic range: ICES waters	✓	✓
Geographic resolution: 0.05° c-squares	✓	✓
Fleet segment Gear resolution: Metier Level 4 gear codes	✓	✓
Species	✗	✓

The geographic extent of the data was cropped to an area of interest that included English waters as well as waters administered by Welsh and Northern Irish fisheries administrations plus a 100km buffer out from those countries' exclusive economic zones.

Non-UK 12-metre and over vessels

The UK fishing authorities receive VMS data for all fishing vessels over 12-metres within UK waters. Currently linked logbook data is not shared consistently from all European countries, so it is not possible to analyse non-UK vessel VMS data with the same confidence and methods that are to be applied to UK 12-metre and over vessels.

Off-the-shelf VMS based fishing activity products of non-UK data in UK waters only include aggregated datasets at ICES rectangle resolution supplied by the European Scientific, Technical and Economic Committee for Fisheries (STECF). There are also products from ICES that record effort (but not landings) from common gear types (but not all gears) at 0.05° c-square resolution. However, anonymity requirements make it impossible to separate UK and non-UK data.

This project therefore derived a dataset from the non-UK VMS data received by UK fishing authorities, linked to the fleet registry which contained gear type at vessel registration, by spatially joining the VMS dataset to a coded 0.05° c-square grid. Only VMS pings which were registered as 'fishing', based upon a speed of between 0 and 6 knots at the time of the ping, were used.

The geodatabase contained the following attributes:

- Temporal extension: 2016-2023
- Temporal resolution: Annual

- Geographic extension: UK waters and surrounding waters
- Geographic resolution: Point data aggregated to 0.05° c-squares
- Fleet segment Gear resolution: Metier Level 4 gear codes

The geodatabase contained the following fishing activity metrics:

- Effort (minutes)

Each VMS ping included a time-stamp, these were used to calculate the amount of time that elapsed between each ping in a trip. By taking half the time from the previous ping and half the time to the next ping, a time value was assigned to each VMS ping.

There were no landings data available for non-UK fishing activity other than STECF data at ICES rectangle resolution. Given the close correlation between fishing activity metrics observed in iterations of this report, no effort was made to analyse non-UK landings data as such coarse data would only generate landings data proxied by effort data. As such this would not be as informative as activity intensity based on effort.

Geospatial Analysis

All geospatial analysis used ArcGIS Pro (ESRI) with map visualisations to the ETRS 1989 co-ordinate systems and Lambert Azimuthal Equal Area Projections. The workflow was as follows:

1. Fishing activity intensity was recalculated to cumulative fishing activity intensity by ranking intensity (from lowest to highest) and cumulated before then scaling to the proportion of total cumulative effort. Proportion of total cumulative effort was the basis for mapping cumulative activity intensity as deciles of cumulative activity i.e., top 10%.
2. The top 80% of fishing activity was top sliced following the thresholds approach agreed for each year to generate year by year core fishing areas.
3. Interannual variability and important areas were then derived by calculating the interannual consistency of core areas, i.e., the number of years over which a particular area was identified as core area.
4. The interannual stability of core areas was assessed using the number of occurrences an area was identified as core within the study period. Important areas were defined from merging the overlapping core areas.
5. Combining important areas from different cuts of data activity metrics was then used to assess spatial overlap e.g.:
    a. Gear types of fleet segments
    b. Species landed from fleet segments
    c. Vessel activity from different ports (each c-square was assigned the list of ports operating in that area, then counted. This produced a heatmap

able to display the areas each port receives catch from the UK 12-metre and over vessels)

6. The changes to the size of important area were tracked for a selection of gear types and landed species from 2016-2023. This was done to determine whether this study has enough data to effectively describe the interannual variability of important areas. This variability is influenced by factors such as natural climate variability, directional climate warming. Should the data be strong enough it may allow for insight to be gained on the stability or changeability of the environment, which in turn may reflect how the UK 12-metre and over fishing fleets adapt to these changes through shifts in important areas. To undertake this analysis the top 80% of proportional effort of gear types or proportional weight of species landed were sequentially combined each year (for example 2016, 2016 + 2017, 2016 + 2017 + 2018). The differences in area size between each year grouping were then recorded.

Exploration of the ‘Important Area’ Threshold

In 2022 the threshold for *significant* fishing activity was determined as the top 80% of fishing activity within any given metric. This was decided because it was the approximate point at which the relationship between fishing activity and fished area started to transition from activity being concentrated in a disproportionally small area to fishing activity being dispersed over a disproportionally large area across when looking at all gears and areas. **Figure 1** demonstrates this relationship.

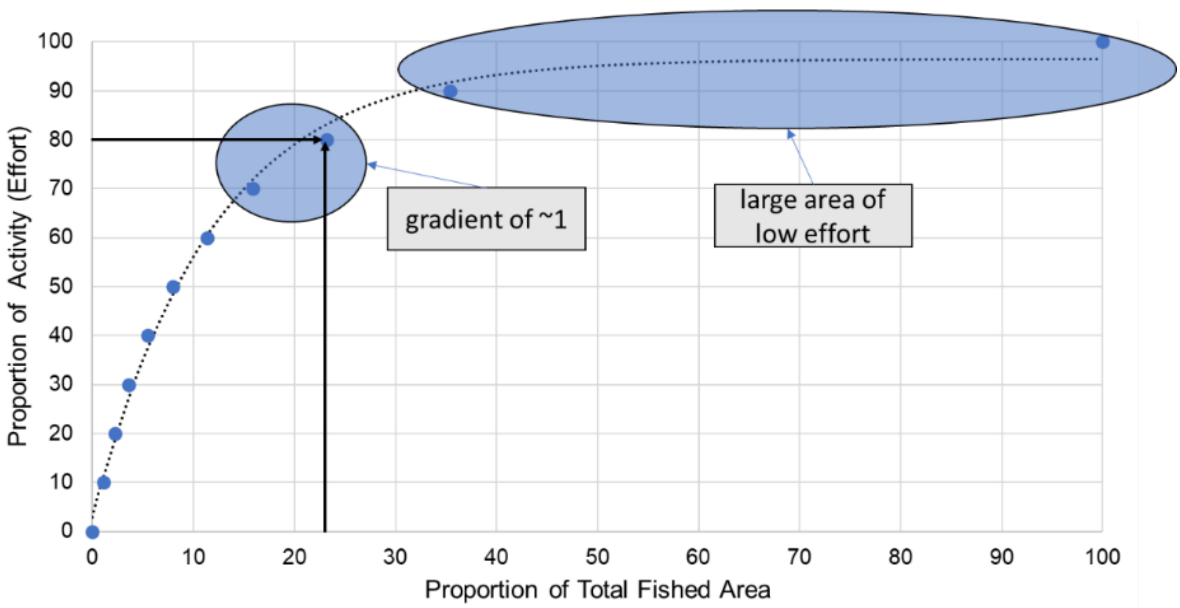


Figure 1. A plot of the proportion of fishing activity (effort kWh) against the proportion of the total fished area, annotated to demonstrate the point at which the gradient of the curve is approximately 1

This theory was tested using the four separate metrics (**Figure 2**) across each year in the 2022 time series (2016 – 2021).

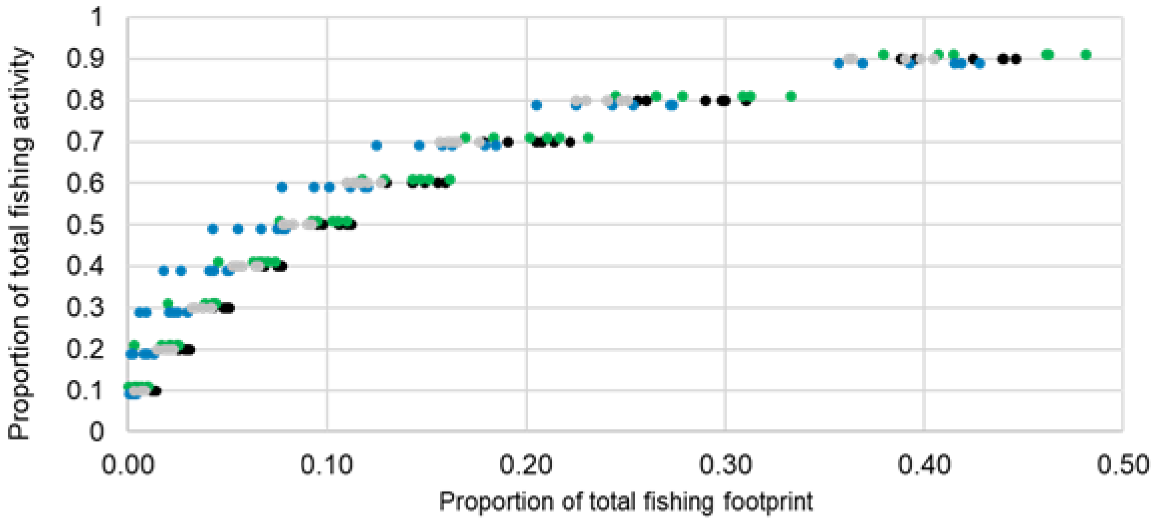


Figure 2. Cumulative activity-area curves for different fishing activity metrics of the UK 12-metre and over fleet segment all 2016-2021. All gears combined, Effort as kWh (black), Landings value as £GBP (green), landings weight as tonnage (blue), and fishing effort as hrs (grey). Data for value and tonnage have been jagged by + and - 1% respectively on the y-axis for visibility.

For this project the method was further developed to explore whether the assumption that at approximately 80% fishing activity the relationship between fishing activity and fished area changed from being disproportionately concentrated over a small area to disproportionately dispersed over a large area could be applied across different breakdowns of the fleet. For each individual permutation of the data analysed, the proportion of the total fishing footprint was plotted against the proportion of the total fishing activity (by metric) in deciles. The gradient between each decile was then calculated using the equation:

Gradient = Change in cumulative proportion of effort / change in cumulative proportion of area

The cumulative proportion of activity was then plotted against the gradients and a linear trendline was fitted to the graph. The equation for the trendline was then recorded and transposed to calculate the proportion of fishing activity at which the gradient was equal to one.

Where fishing activity data was too sparse to produce changes in area across each decile of cumulative proportion of activity (for example in less common gear groupings) the gradient couldn't be calculated for across all deciles. These years of data were not included in the final averages.

Quality Assurance Process

Data exports from GeoFISH were quality assured by the MMO Statistics team. Quality assurance of the data underpinning the commission indicates sufficient confidence in the data to provide these maps. Please note that quality assurance was completed at pace, and discussions are being held with Cefas surrounding some of the points revealed in Annex 2.

The steps taken to quality assure, fix, and extract data for use are summarised below.

Step 1 - QA and crosschecks

1.1 GeoFISH dataset integrity checks (data validation)

- Check for records with incomplete values, Not Applicables (NAs) or blanks
- Checks for maximum and minimum recorded weight, value, speed and effort hours
- Check for zero weight, value and effort records
- Check for high effort with low value
- Check for extreme high prices (i.e. >20 per kg and >50 per kg)
- Check for extremely low price per kg
- Check what proportion of weight in English waters was missing value before fix
- Check various example cases to determine how they are be processed from iFish2 through to the GeoFISH output
- Check GeoFISH tables 1 and 2 and ensure the totals matched

1.2 GeoFISH crosscheck vs alternative datasets (data verification)

- Check raw VMS data for how many NULL fishing speed records to expect (which have been culled from GeoFISH during cleaning step, mainly appears to be from VMS 12-metre and over vessels sending additional intermediary pings)
- Compare overall UK 12-metre and over fleet landings weight between MMO Sea Fisheries Statistics published landings, MMO VMS-linked method and GeoFISH table 1 and table 2:
    - Weight by year
    - Weight by rectangle
    - Weight by vessel
    - Value by year
    - Value by rectangle

    - Value by vessel
- Compare UK 12-metre and over activity in English waters rectangles only:
    - six outputs as above
    - Investigate major rectangle weight and value mismatches between datasets
- Compare UK 12-metre and over data for the study area only:
    - Check all GeoFISH c-squares fall within the study area c-square layer
    - Compare GeoFISH v5 vs GeoFISH 2022 work vs MMO VMS-activity dataset vs MMO VMS ad hoc data for weight, value and effort by year
    - Compare top vessels by effort hours between datasets
    - Investigate cases where there are large differences in weight, value or effort between different datasets

Step 2 - Fixes

- Produced a vessel list year/month lookup and used that to apply missing vessel country codes to GeoFISH table 1 and table 2 for approximately 600 vessels.
- Identified records of price greater than £50 per kg and converted to zero
- Found all zero value records in GeoFISH
- Imported average species price per kg from MMO annual Sea Fisheries Statistics landings publication underlying databases and applied these to GeoFISH zero value records in table 1 (at species level for species that exist in GeoFISH dataset or a broad 'Other species' average prices if not one of the target species)
- Used approach to apply these value corrections to the table 2 GeoFISH data to ensure the outputs match exactly post fix

Step 3 - Extracts

- Formatting and data handling to prepare data for work in ArcPro

Detected issues summary

- Fixed (full)
    - Records with missing vessel nationality
- Fixed (partial)
    - A partial fix was applied which fixes extreme high prices and zero prices to better align with MMO Sea Fisheries Statistics landings in some cases. However, due to being applied at aggregated levels the lack of specificity in price per kg that had to be applied to certain records causes likely overestimation of value in certain cases (i.e. moves from zero value under-report of value to overestimate of value)
- Unresolved

- Likely logic issue with speed profiles being applied for certain gear types
- Landings and VMS match conserve over-applies assumptions by apportioning out unmatched logbooks to different vessels from the vessel that reported landing making QA difficult
- Unmatched effort is either being apportioned using too broad assumptions or is dropped during cleaning, with it being difficult to determine which. Effort figures appear lower than 2022 GeoFISH output and it is unclear why.
- Weight mismatches, mainly missing Scottish landings and only minor differences in English water rectangles. GeoFISH method reallocates reported landings to different ICES rectangles making QA checks/comparisons more difficult. For certain vessels GeoFISH current method is inappropriate (i.e. a vessel was identified to likely have ~1400 tonnes of mackerel allocated to it which was caught by a different vessel due to the over applied conserve function, however as the dataset is aggregated beyond individual vessel level for this work this should not cause significant issues). In other cases GeoFISH looks to be correctly reallocating landings using VMS that appears to be misreported in logbooks.

Results

Describing fishing

Activity by metrics and gears

Patterns in UK 12-metre and over fishing activity distribution remain consistent with those examined in 2022, where the intensity of fishing activity varies spatially around the UK with particularly intense activity occurring on the north-east of England, eastern and western Channel and north of the Irish Sea around the Isle of Man. General areas of high fishing activity intensity remain consistent across all metrics, however there is some minor variation as shown by **Figure 3**.

The relationship between the proportion of the total fishing activity and the proportion of the total fished area also varies depending on the metric explored, with the top 90% of effort in hours being concentrated to a smaller proportion of the total fished area compared to the other three metrics, as shown in **Figure 4** and **Table 4**.

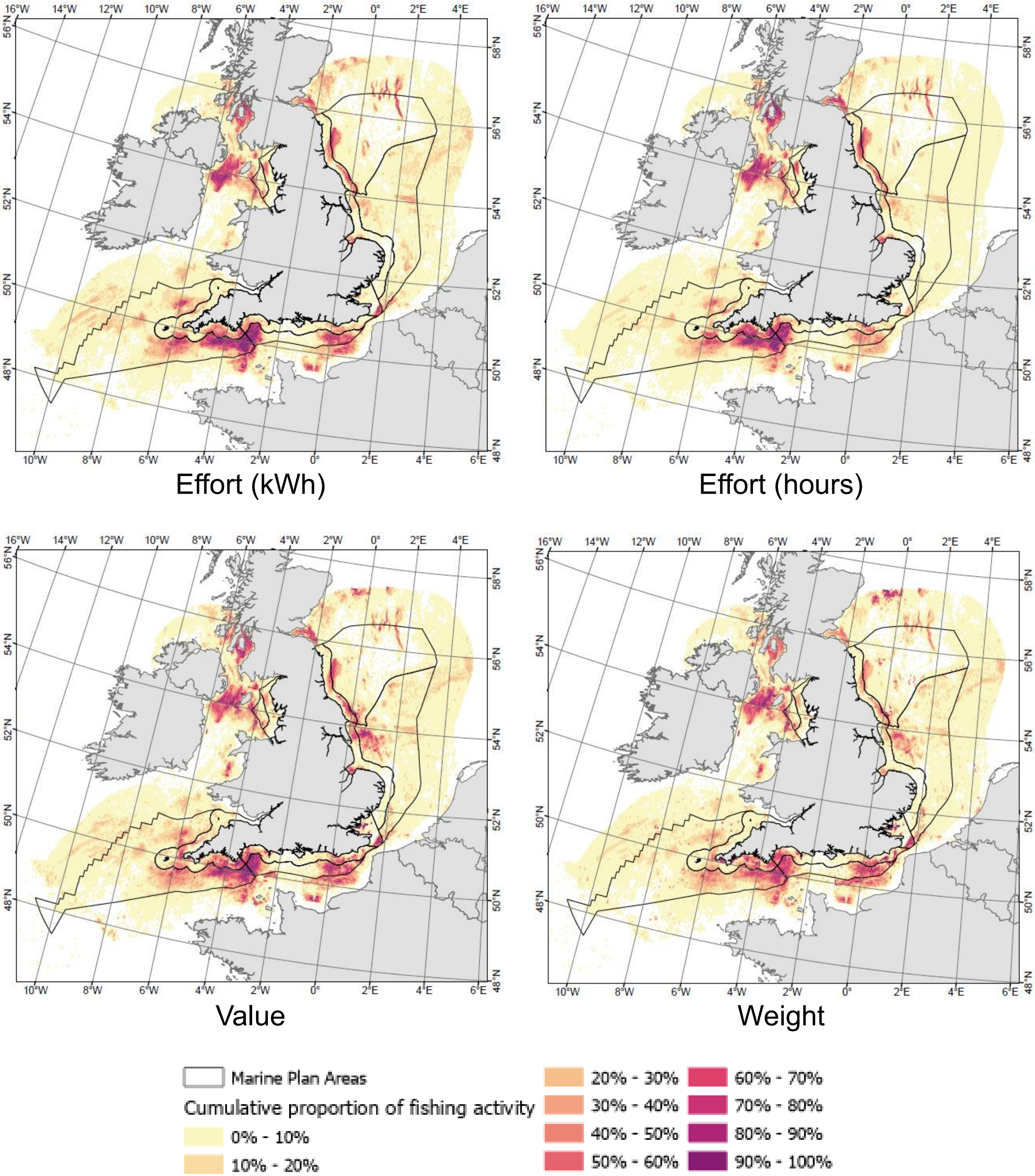


Figure 3. Spatial distribution of fishing activity for the UK 12-metre and over fleet 2016-2023, visualised using the cumulative proportion of fishing activity by metrics: effort in kilowatt hours (top left), effort in hours (top right), value (bottom left), and weight (bottom right).

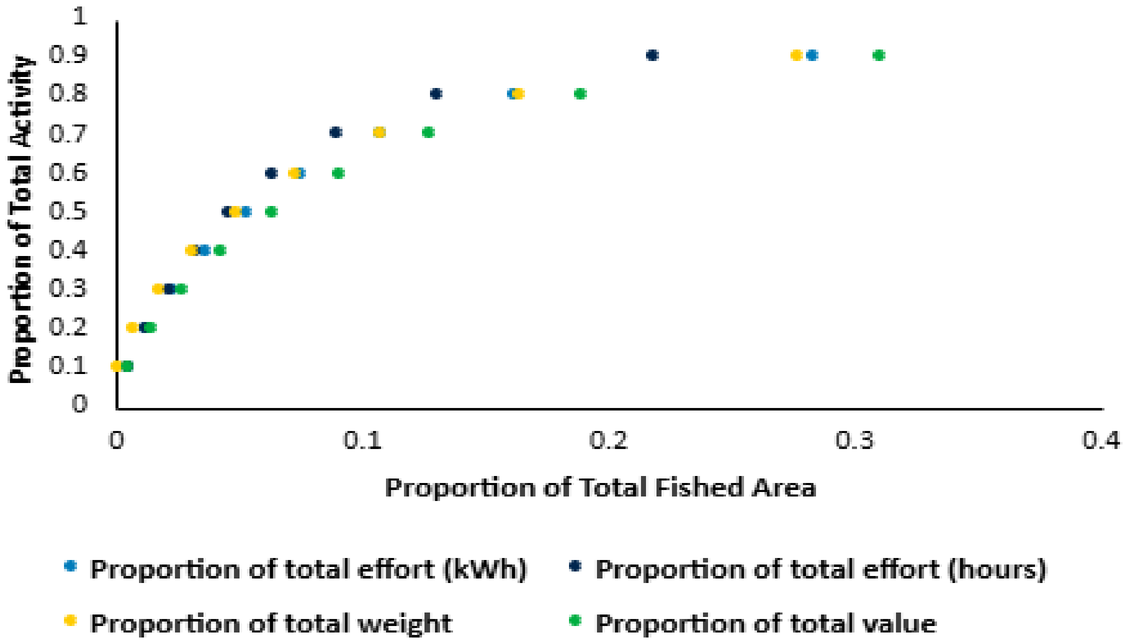


Figure 4. Cumulative activity-area curves for different fishing activity metrics of the UK 12-metre and over fleet segment all 2016-2023; light blue for total effort (kWh), dark blue for total effort hours, yellow for total weight and green for total value.

Table 4. Cumulative activity-area curves for different fishing activity metrics of the UK 12-metre and over fleet segment all 2016-2023.

	Effort (kWh)		Effort (hrs)		Landings (t)		Landings (£)	
% of total fishing activity	Area (km²)	% of total	Area (km²)	% of total	Area (km²)	% of total	Area (km²)	% of total
10	2198	5.0	2374	0.6	769	0.2	2174	0.5
20	5554	1.3	5514	1.3	3336	0.8	6199	1.5
30	9995	2.4	9302	2.2	7558	1.8	11607	2.7
40	15530	3.7	13949	3.3	13366	3.2	18440	4.3
50	22556	5.3	19721	4.7	21072	5.0	27149	6.4
60	31908	7.5	27357	6.5	31320	7.4	38473	9.1
70	45570	10.7	38105	9.0	45893	10.8	54411	12.8
80	69036	16.3	55462	13.1	69559	16.4	80391	19.0
90	120500	28.4	92934	21.9	117765	27.8	131797	31.1
100	424038	100.0	424038	100.0	424038	100.0	424038	100.0

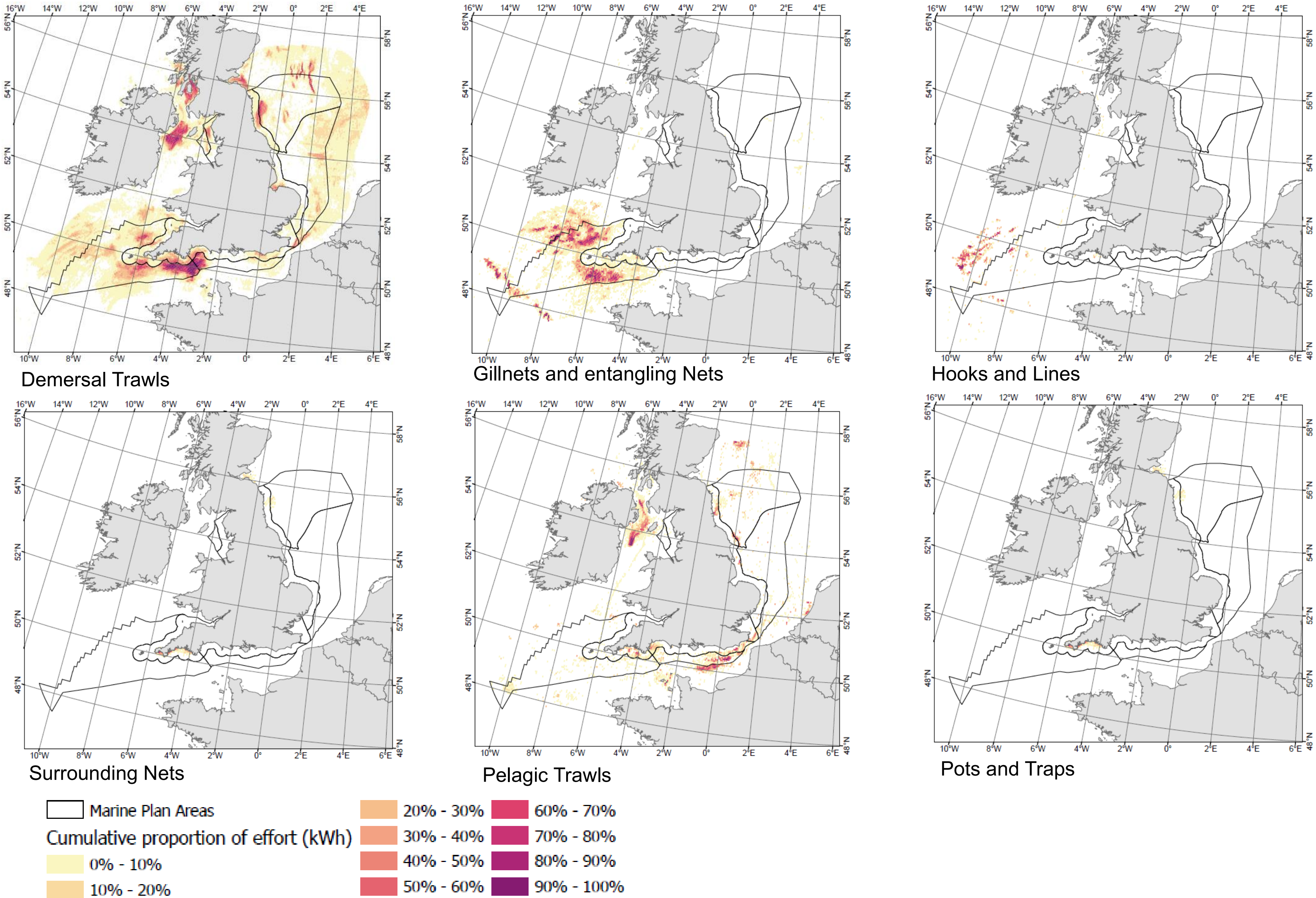
Conversely, gillnets and entangling nets are common off the southwest coast of England, with less well-defined areas of higher fishing effort.

There is sparse pelagic trawling activity throughout the whole of the study area, with the highest concentrations of activity occurring in western English Channel and in the north of the Irish Sea.

Pots and traps display many small hotspots of effort around the coast, with the largest hotspot located off the coast between the Humber Estuary and Flamborough Head.

Less commonly used gears such as surrounding nets and hooks and lines display a much smaller geographic range, with surrounding nets only having a single highly concentrated area of effort in the inshore area of south Cornwall and Devon and hooks and lines having numerous scattered hotspots of effort predominantly outside the EEZ in the Celtic Sea.

Figure 5. [Next Page] Spatial distribution of fishing activity for the UK 12-metre and over fleet 2016-2023, visualised using the cumulative proportion of fishing effort (kWh) across 6 gear groupings: demersal trawls (top left), gillnets and entangling nets (top centre), hooks and lines (top right), surrounding nets (bottom left), pelagic trawls (bottom centre), and pots and traps (bottom right).


Demersal Trawls
Gillnets and entangling Nets
Hooks and Lines
Surrounding Nets
Pelagic Trawls
Pots and Traps
Marine Plan Areas
Cumulative proportion of effort (kWh)
0% - 10%
10% - 20%
20% - 30%
30% - 40%
40% - 50%
50% - 60%
60% - 70%
70% - 80%
80% - 90%
90% - 100%

Activity by target species

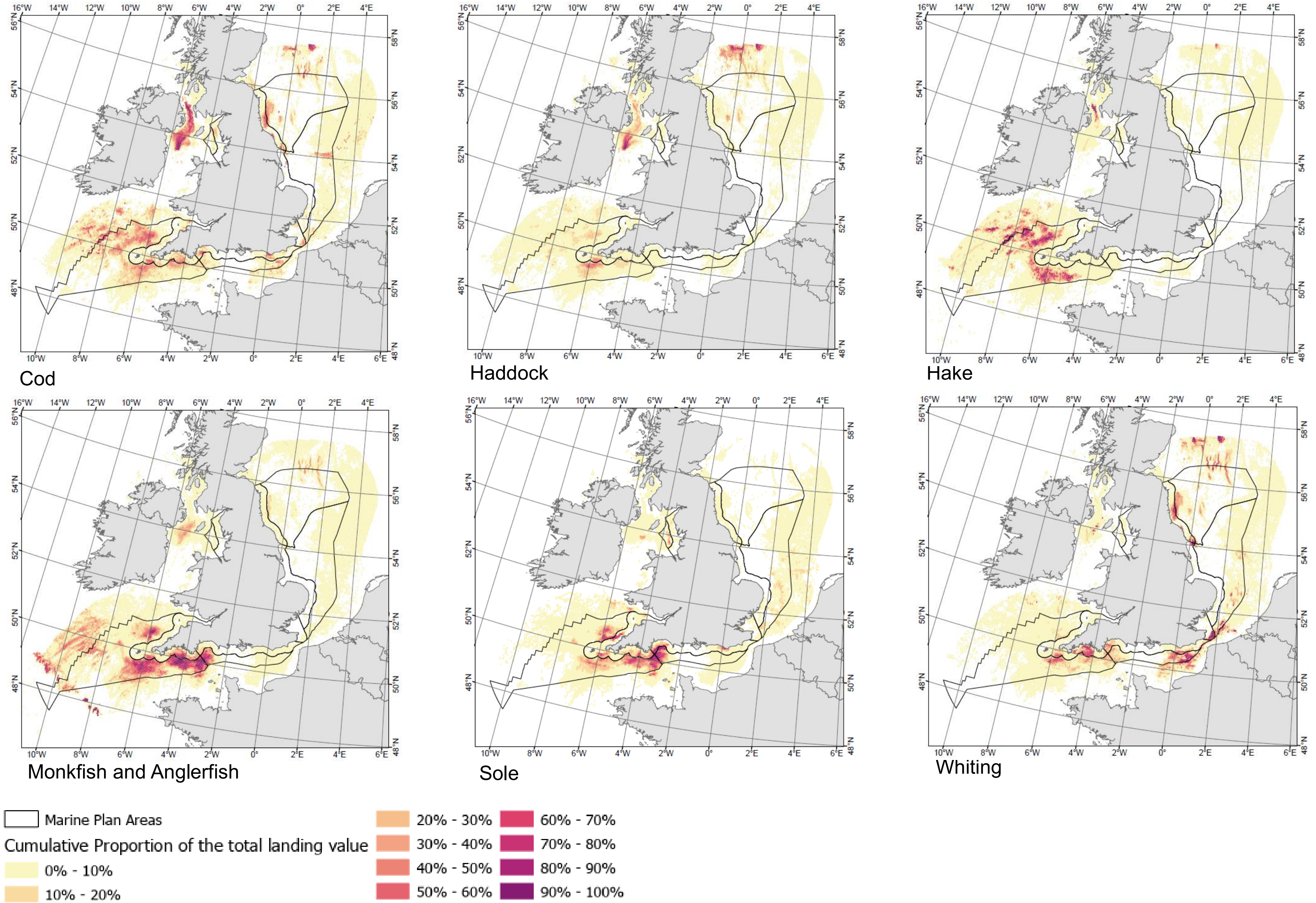
Figure 6 displays the spatial distribution of landing value for the 6 target demersal fish species. Cod show well defined areas of high value in the north of the Irish Sea, in the northeast of England and off the east coast of Scotland at the limit of the study area, as well as a more dispersed area of high landing value in the Celtic Sea. There are also smaller hotspot areas for cod landings in the eastern English Channel, and North Sea.

High value areas of haddock are more concentrated than that of cod, with hotspots in the north of the Irish Sea, off the southwest of Cornwall, and off the east coast of Scotland at the limit of the study area.

Both hake and monkfish and anglerfish have the largest proportion of their value landed from the southwest of England in the Celtic Sea, each with a smaller well-defined hotspot of landing value in the north of the Irish Sea, with monkfish and anglerfish hotspots also extending into western English Channel.

Sole are most commonly landed from the Celtic Sea around and the western English Channel. Whiting are mainly landed from hotspots in the eastern and western English Channel, the northeast of England, and the North Sea.

Figure 6. [Next Page] Spatial distribution of fishing activity for the UK 12-metre and over fleet 2016-2023, visualised using the cumulative proportion of landing value across 6 target demersal fish species: cod (top left), haddock (top centre), hake (top right), monkfish and anglerfish (bottom left), sole (bottom centre), and whiting (bottom right).


Cod
Haddock
Hake
Monkfish and Anglerfish
Sole
Whiting
Marine Plan Areas
Cumulative Proportion of the total landing value
0% - 10%
10% - 20%
20% - 30%
30% - 40%
40% - 50%
50% - 60%
60% - 70%
70% - 80%
80% - 90%
90% - 100%

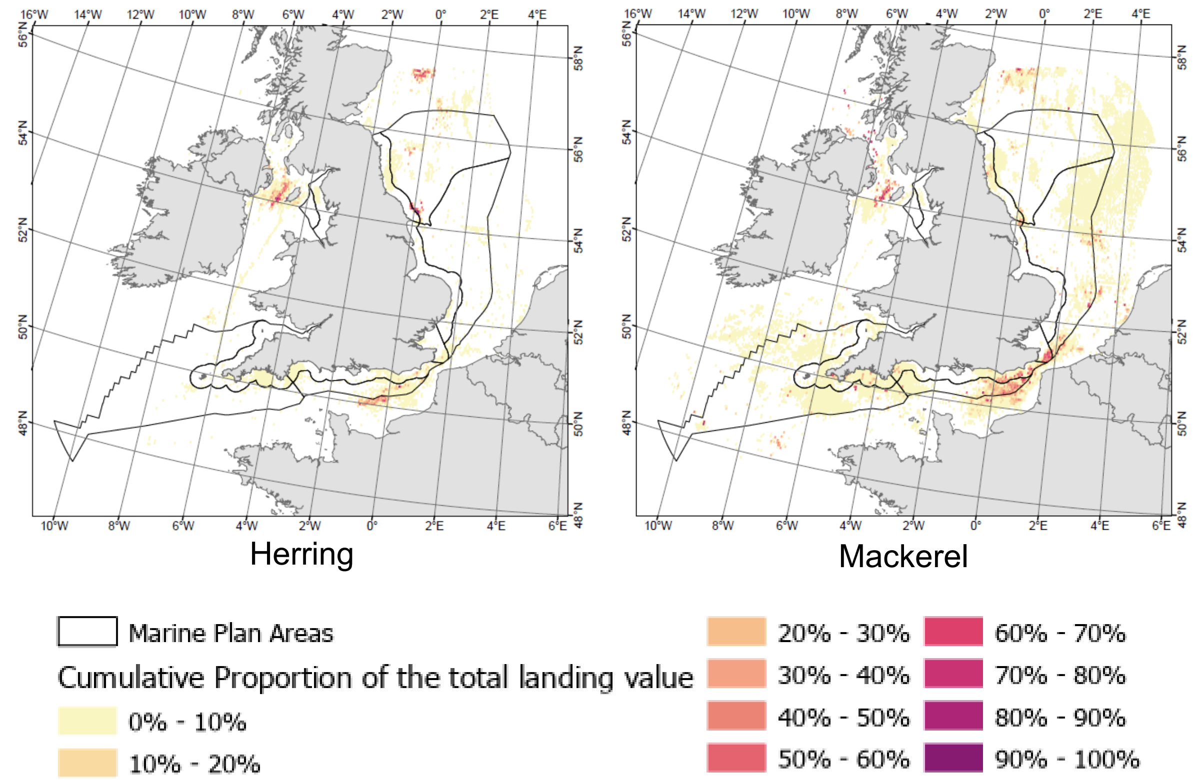


Figure 7 Spatial distribution of fishing activity for the UK 12-metre and over fleet 2016-2023, visualised using the cumulative proportion of landing value across 2 target pelagic fish species: herring (left) and mackerel (right).

Figure 7 displays the spatial distribution of landings for the two target pelagic species, both showed hotspots in the Irish Sea off the west coast of the Isle of Man, in the eastern English Channel, and a small hotspot just north of Flamborough Head. In general, landings for mackerel were most dispersed, with relatively lower landings values also being landed over large areas of the western English Channel, Celtic Sea, and North Sea.

Figure 8 highlights the spatial distribution of landing value for nephrops and scallops. Nephrops are caught across the Celtic Sea and North Sea, with well define hotspots of high value in the north of the Irish Sea off the coast of the Isle of Man, around the Isle of Arran, in the northeast of England, and around the Firth of Forth. Scallops are also caught in the Celtic Sea and the North Sea around Dogger Bank, however strong hotspots occur in the eastern and western English Channel, the northeast of England close to and just north of Flamborough head, around the Isle of Man, and with a few smaller hotspots in Cardigan Bay.

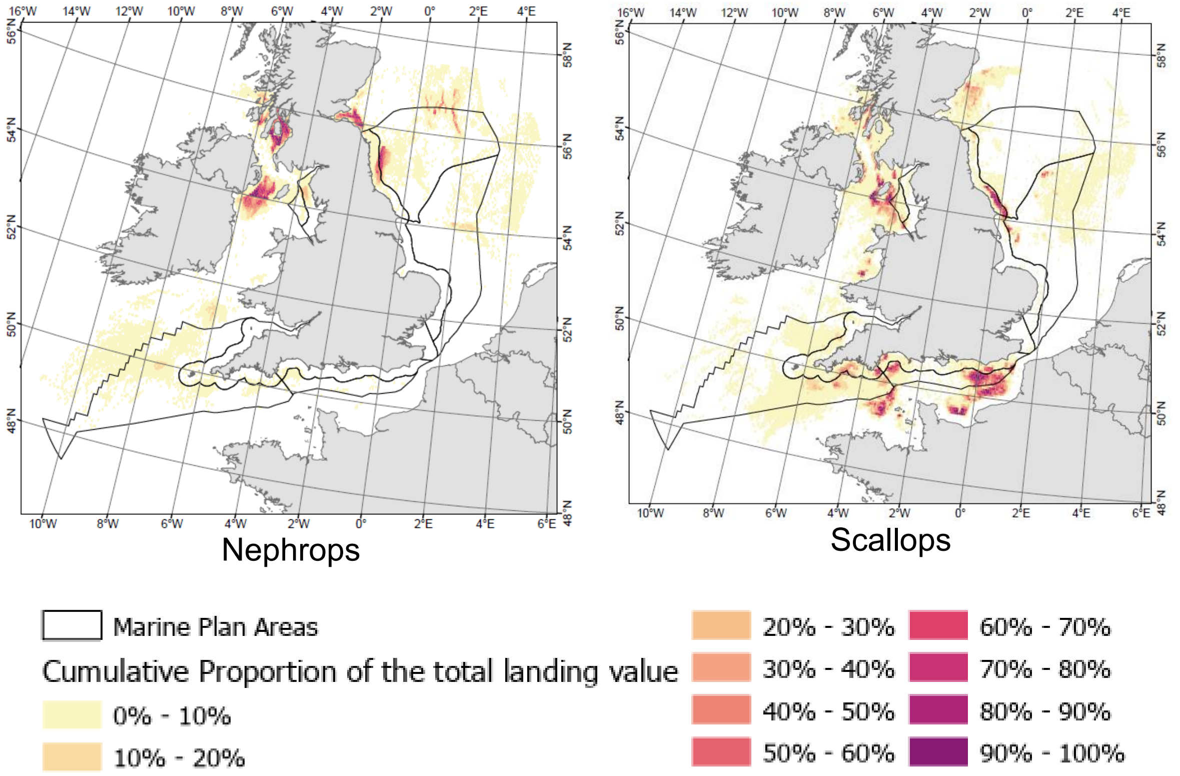


Figure 8 Spatial distribution of fishing activity for the UK 12-metre and over fleet 2016-2023, visualised using the cumulative proportion of landing value across 2 target dredged/trawled demersal invertebrate species: nephrops (left) and scallops (right).

Figure 9 displays landing value for crabs, the only selected target species caught with static gear. Crabs are caught throughout the much of the Celtic Sea and North Sea, however there are multiple dispersed hotspots off the east of England, in the western English Channel, in the inshore are of the Celtic Sea, and with some weaker hotspot in the north of the Irish Sea and off the west coast of Scotland.

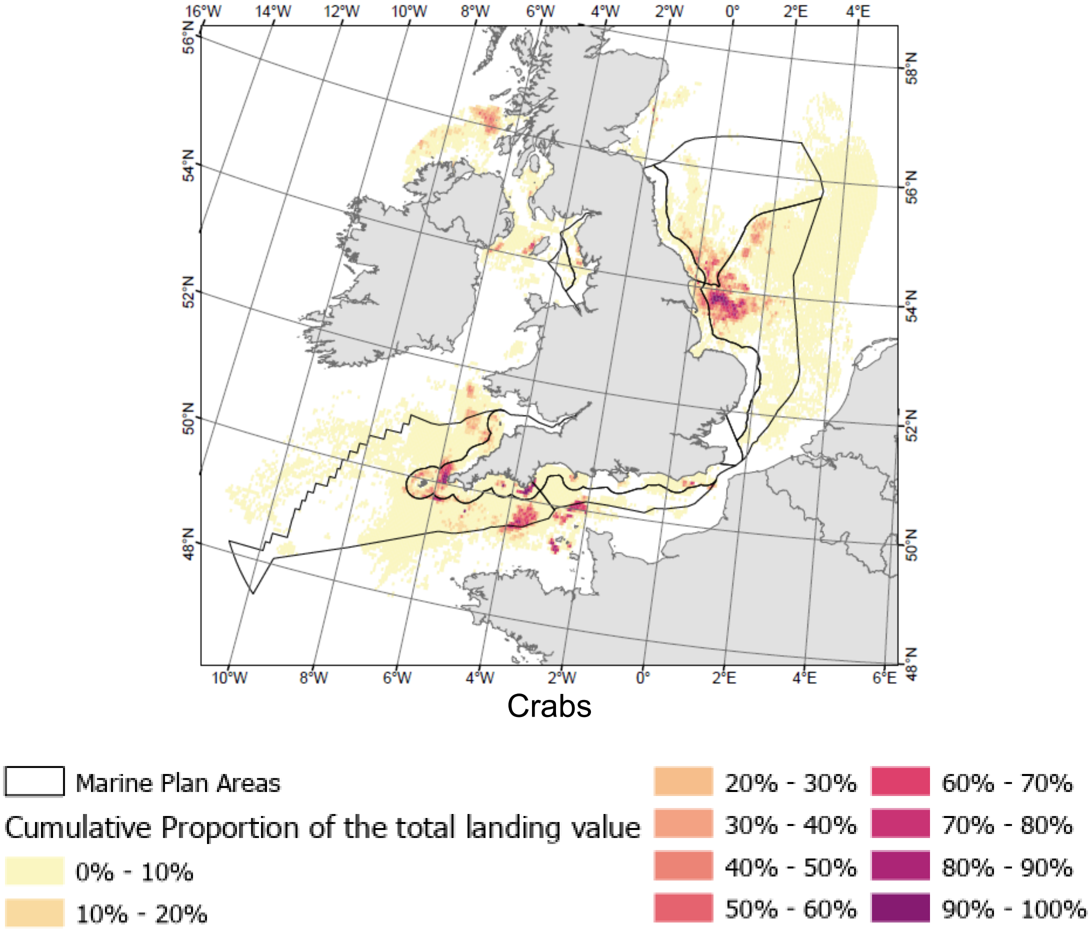


Figure 9 Spatial distribution of fishing activity for the UK 12-metre and over fleet 2016-2023, visualised using the cumulative proportion of landing value across for crabs.

Fishing from ports

Through combining the individual port datasets, of UK vessels landing into both UK and non-UK ports, a count of the ports that vessels land their catch at can be produced. When mapped out this shows hotspots of vessel activity associated with UK and European ports (**Figure 10**). The c-square with the greatest number of ports operating within (23 ports) is located on the south east side of the Isle of Man. However, the c-square in England with the greatest number of ports operating within in (20 ports) is in the north-east, near Newcastle Upon Tyne.

The ports that land catch from the greatest and smallest areas are listed in **Tables 5 and 6**. As found in previous MMO fisheries mapping reports, Newlyn in south west England remains a highly active port, with the vessels landing at this port contributing to the greatest area of fishing activity (**Figure 10**, **Table 5**). Following Newlyn, UK vessels landing at two Dutch ports, Harlingen and Ijmuiden, contribute the next greatest areas of fishing activity; as well as two UK ports in Brixham, in on the south coast in England, and Peterhead, in north east Scotland (**Table 5**).

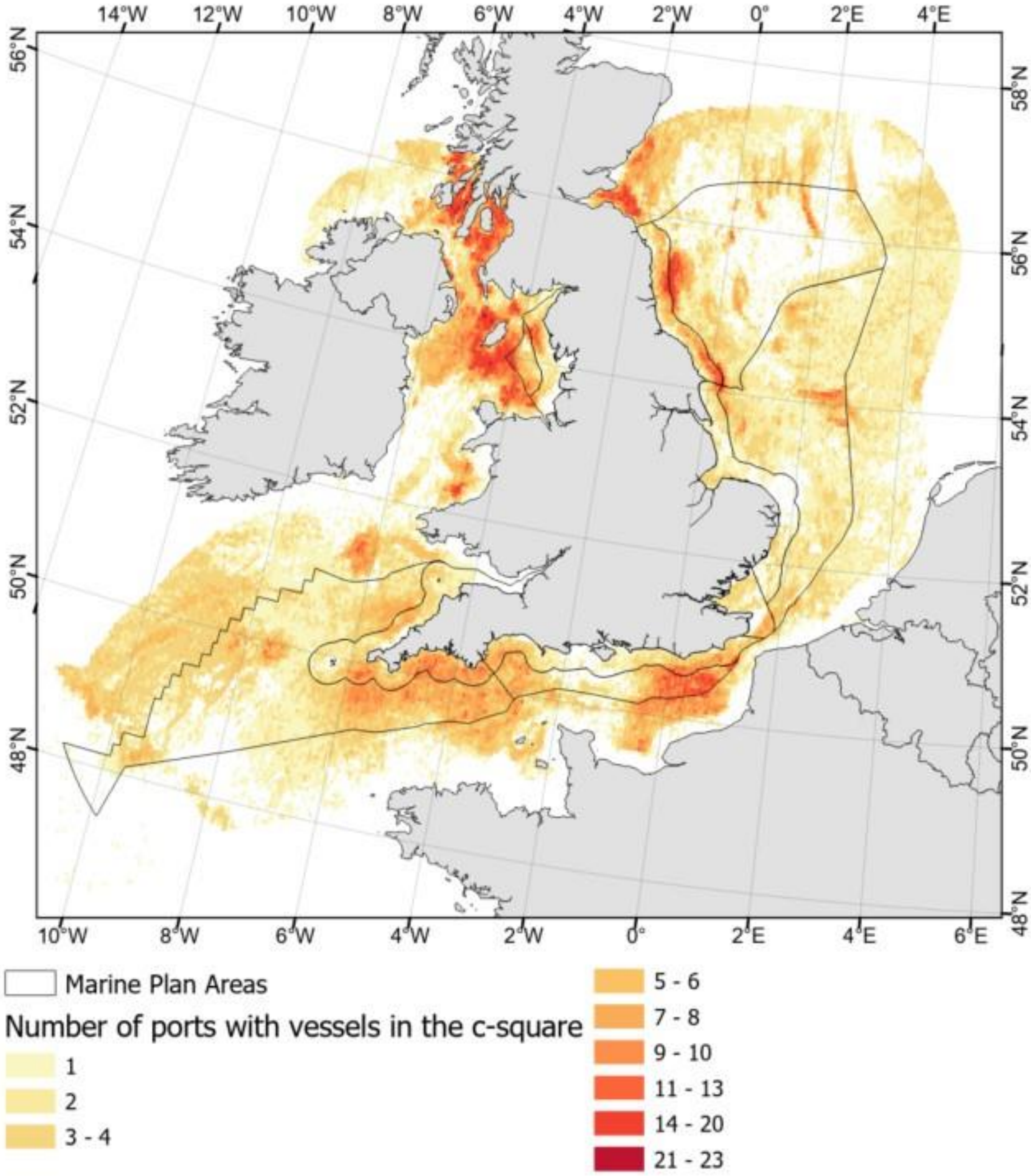


Figure 10. Map showing the number of ports operating around the UK, per c-square, based on fishing activity for the UK 12-metre and over fleet 2016-2023.

Table 5. The greatest area and number of c-squares covered by UK 12-metre and over vessels by the port the catch is landed at 2016-2023.

Port	Area Covered by Vessels (km^2)	No. c-squares
Newlyn, England	105,092	5272
Harlingen, Netherlands	62,928	3529
Ijmuiden, Netherlands	53,459	2908
Brixham, England	52,315	2634
Peterhead, Scotland	44,278	2556

The ports that land catch from the five smallest areas are mostly located in western Scotland, Northern Ireland and Ireland, with the addition of one English port Exmouth on the south west coast (**Table 6**). Vessels landing at the port in Arran cover a small area, yet some of the greatest counts of ports are landing catch from this area (**Figure 10**, **Table 6**). When looking at the ports that feature in this area they are mostly small ports located in western Scotland and Northern Ireland. This demonstrates how a series of small ports can use a nearby common area to produce a hotspot of vessel activity.

Table 6. The lowest area and number of c-squares covered by UK 12-metre and over vessels by the port the catch is landed at 2016-2023.

Port	Area Covered by Vessels (km^2)*	No. c-squares
Ardrishaig, Scotland	17	1
South Uist and Eriskay, Scotland	17	1
Carrickfergus, Northern Ireland	18	1
Cushendall, Northern Ireland	18	1
Dún Laoghaire, Ireland	19	1
Exmouth, England	20	1
Arran, Scotland	35	2

* Because c-squares are based on 0.05 latitude and longitude grids, the surface area of each c-square varies in space, decreasing with increasing latitude.

To help validate the effectiveness of producing regional maps of fishing activity based on the landing port, individual ports were visualised. The ports selected were based on a high, medium and low area coverage of UK vessels landing at these ports (Newlyn, Barrow and Exmouth respectively). When displaying the spatial data for a port which lands from a wide area such as Newlyn, using the number of other ports which also land from that area to visualise the data, it becomes clear that a heatmap effect is produced (**Figure 11**). This heatmap effect allows for more detailed interrogation of the patterns on the map, which demonstrate areas where fish landings are shared by multiple different ports, as well as areas from which Newlyn is the only port to land catch.

In contrast, when mapping the extent from which Exmouth land catch only a single c-square appears, offering little useful information about variation in local importance (**Figure 12**). The area from which Barrow lands catch is larger and shows that almost all of that area is also used by multiple other ports (**Figure 12**).

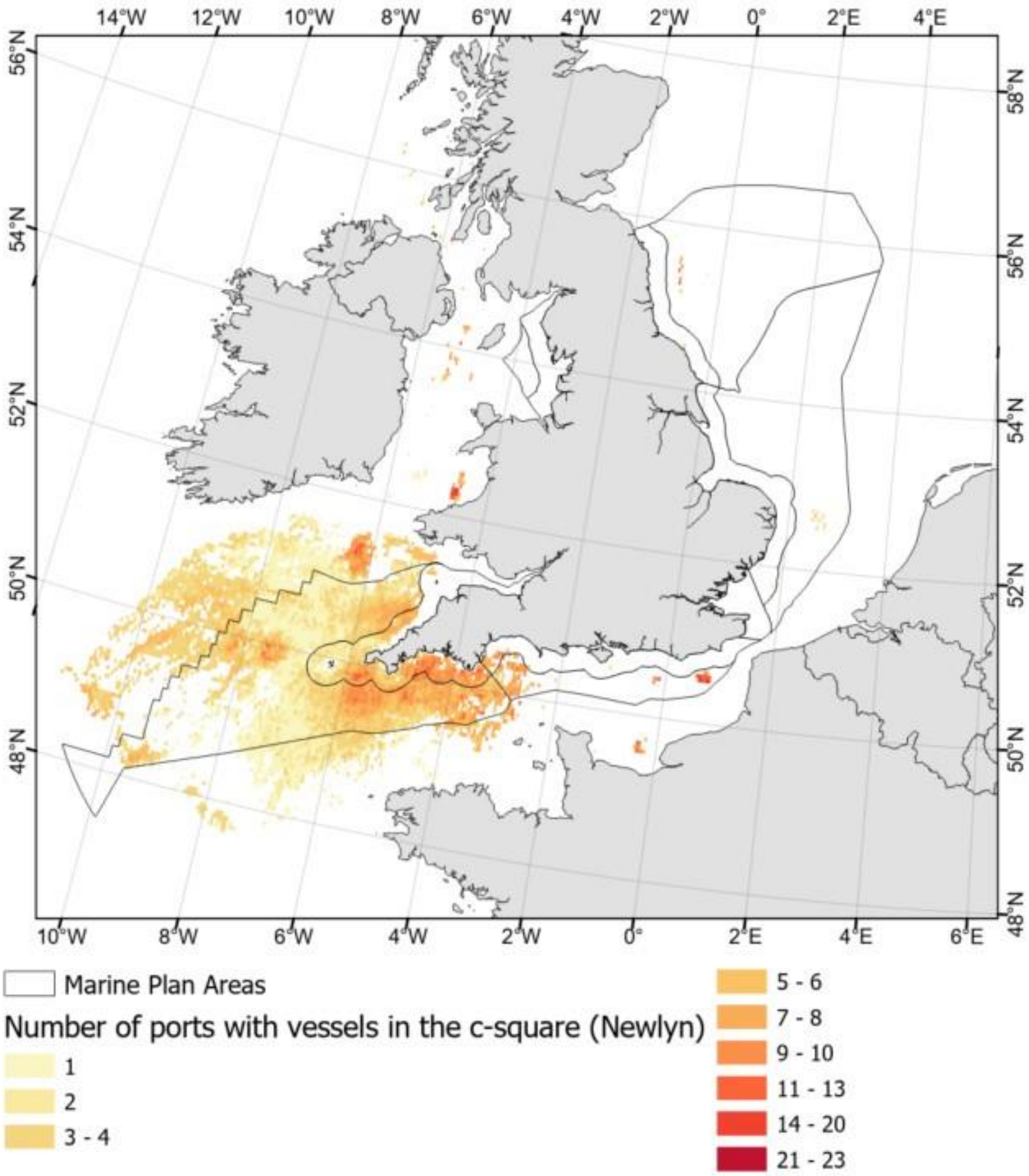


Figure 11. Map showing the number ports landing catch in the same area as Newlyn also lands catch, based on fishing activity for the UK 12-metre and over fleet 2016-2023.

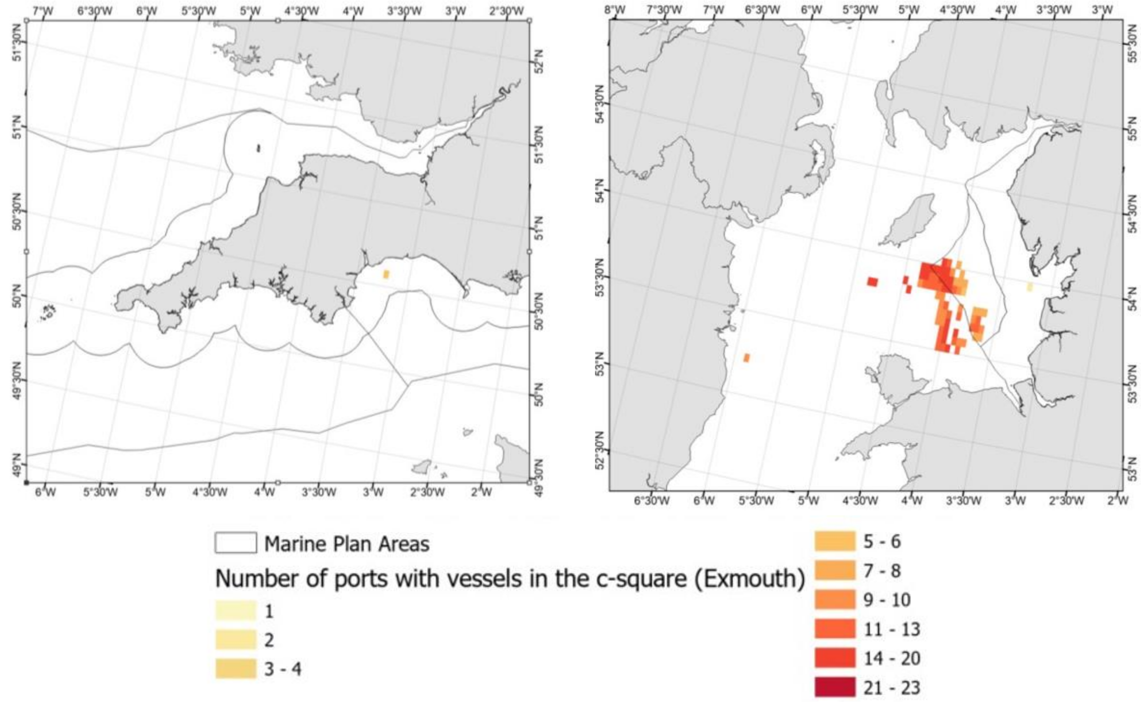


Figure 12. Map showing the number of ports landing catch in the same area as Exmouth (left) and Barrow (right) based on fishing activity for the UK 12-metre and over fleet 2016-2023.

Additionally, the fished area from selected ports were visualised to compare the areas used by smaller ports to the nationally important fishing areas (**Figure 13**). When mapping the fished areas of Ipswich and Bembridge against the nationally important fishing areas for UK 12-metre and over vessels there is very little overlap. Most of the blue and red c-squares for each port's fished areas are located away from the UK nationally important areas heatmap. This shows that there are areas around the coastline that are valuable to nearby small ports and coastal communities that are not important at the national scale.

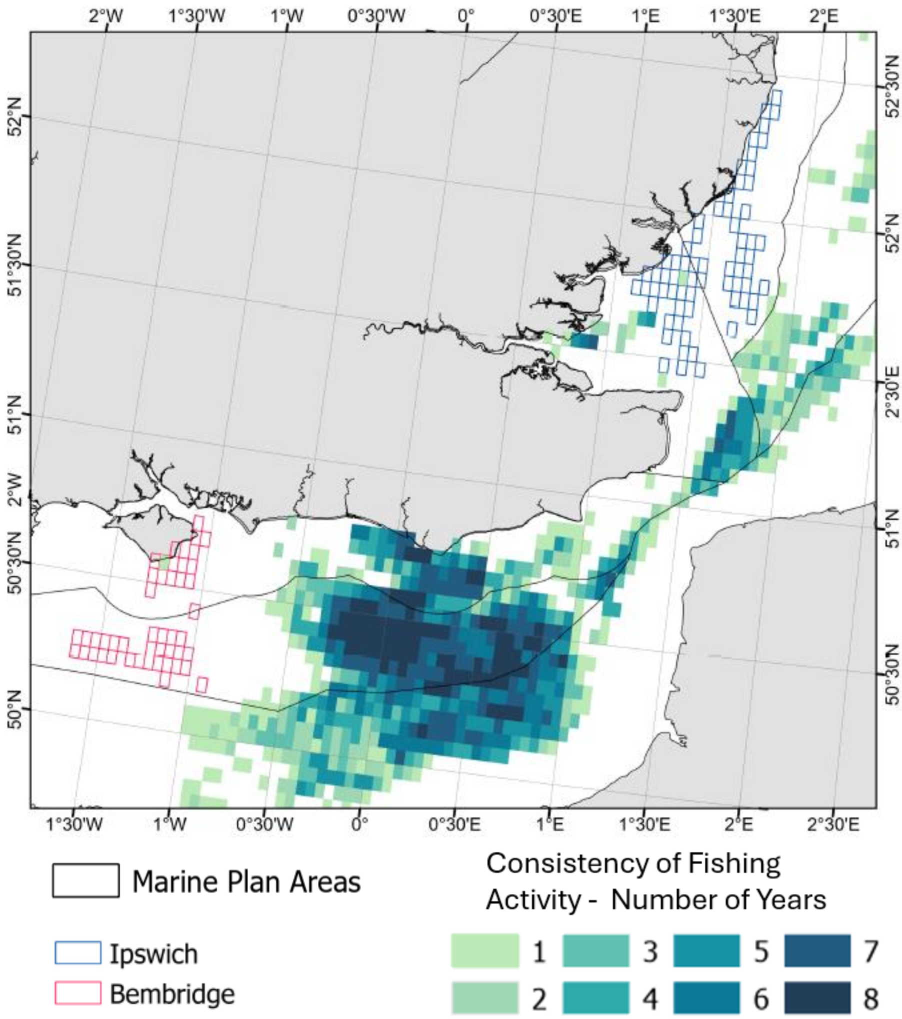


Figure 13. Map showing the areas of vessels landing catch at the ports of Ipswich (blue) and Bembridge (red), and the important fisheries areas for the UK 12-metre and over fleet across all gears using effort (kWh) 2016-2023.

Mapping Important Areas

Important areas by metrics and gears

With an additional two years in the time series, important areas for all gears combined remained consistent with those mapped in 2022. **Figure 14** highlights that where there is consistency in core areas across areas for 2 or more years, the areas are generally consistent across the different metrics. However, there is more variability between metrics where c-squares only register as a core area for a single year, particularly in the North Sea around Dogger Bank and in the Celtic Sea. There is also an area which is consistently a core area when looking at the value and weight metrics between Flamborough Head and The Wash which does not show as an important area when looking at either of the effort metrics.

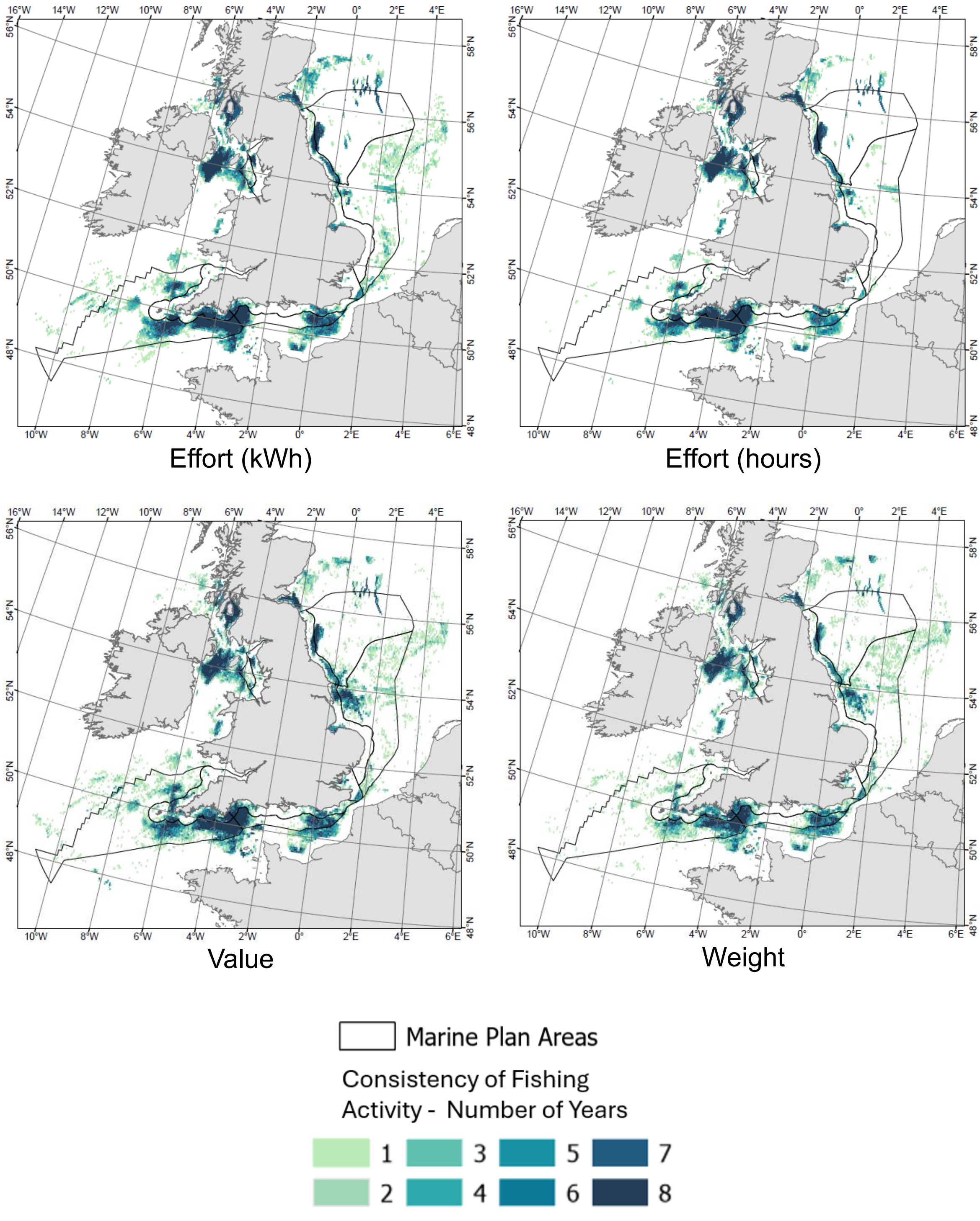


Figure 14. Important fisheries areas for the UK 12-metre and over fleet across all gears using effort (kWh) (top left), effort (hours) (top right), value (bottom left), weight (bottom right) 2016-2023.

The size of the important areas varies with the metric used, as displayed in **Table 7**. The value metric produces the largest important area, at 136674km^2, while effort (hours) produces the smallest important area, measuring 85413km^2.

Table 7. Area (km^2) breakdown of important areas by the number of years and by metric.

Number of Years	Weight (km^2)	Value (km^2)	Effort (kWh) (km^2)	Effort (hours) (km^2)
1	45937	47229	37478	17867
2	19726	21961	17778	11316
3	11755	12175	11613	7873
4	9106	8991	9112	7056
5	7549	8148	8191	6602
6	7390	8372	7360	6520
7	7538	8910	9925	7487
8	12788	20884	21357	20687
Total area	121794	136674	122817	85413

Table 8 provides a breakdown of the percentage contribution towards the whole important area by the number of years for each metric. Among the weight, value, and effort (kWh) metrics, the largest proportion of the important areas were formed of areas which were only a core area for a single year, with each having at least 30% of their important areas made up of c-squares from only one core area. Both the weight and value metrics second largest contribution came from areas that were classed as core areas for 2 years, followed by areas which were classed as core areas for all years in the time series. Effort (hours) was the outlier, with the largest proportion (24.22%) of the important area being made up of areas which were core areas for all years of the time series.

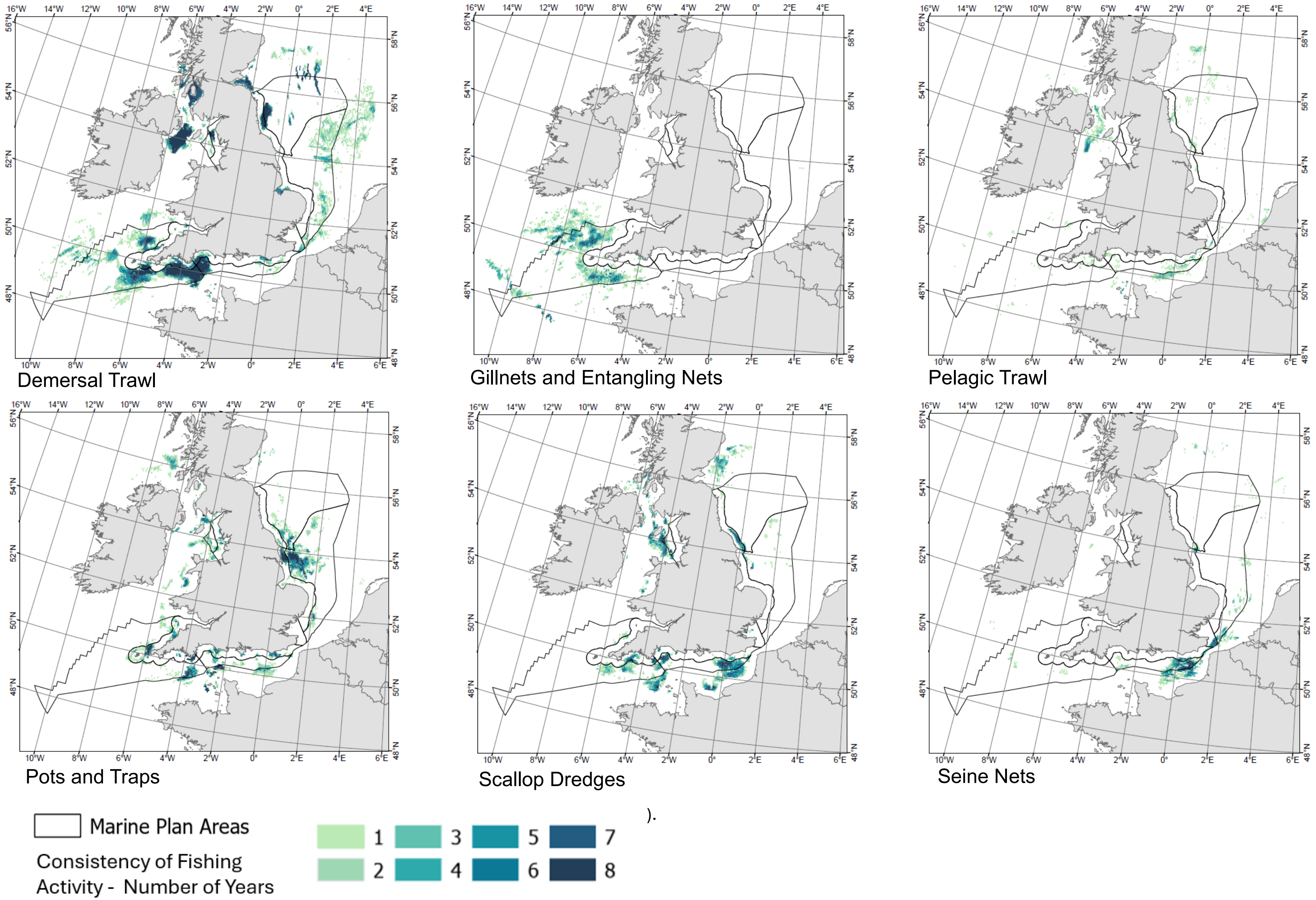
Table 8. Percentage contribution towards the total important area by number of years and by metric.

Number of Years	Weight (%)	Value (%)	Effort (kWh) (%)	Effort (hours) (%)
1	37.72	34.56	30.52	20.92
2	16.20	16.07	14.48	13.25
3	9.65	8.91	9.46	9.22
4	7.48	6.58	7.42	8.26
5	6.20	5.96	6.67	7.73
6	6.07	6.13	5.99	7.63
7	6.19	6.52	8.08	8.77
8	10.50	15.28	17.39	24.22

Important areas by gear grouping

Figure 15 demonstrates that there is a large degree of variability in important areas based upon the gear grouping. Demersal trawls show important areas across large areas of the western English Channel, Celtic Sea, north of the Irish Sea, east and west Scotland within the boundary of the study area, northeast England, and offshore in the North Sea. Gillnets and entangling nets important areas are almost exclusively limited to the Celtic Sea and western English Channel, with a few isolated c-squares elsewhere. Important areas for pelagic trawls show dispersed c-squares groupings and isolated c-squares across the Celtic and North Seas, with more consistently fished important areas in the eastern English Channel and in the north of the Irish Sea. Both pots and traps and scallop dredges have similar important areas, though with only limited overlap, located around most of the English coast with some small important areas in Cardigan Bay and the Isle of Man. Important areas for seine nets are mainly located in the eastern English Channel, with another consistently used important area off Flamborough Head and some isolated dispersed important areas else.

Figure 15. [Next Page] "Important areas" for UK 12-metre and over vessel 2016-2023 using the effort (kWh) metric across the 6 gear groupings: demersal trawls (top left), gillnets and entangling nets (top centre), pelagic trawls (top right), pots and traps (bottom left), scallop dredges (bottom centre), and seine nets (bottom right



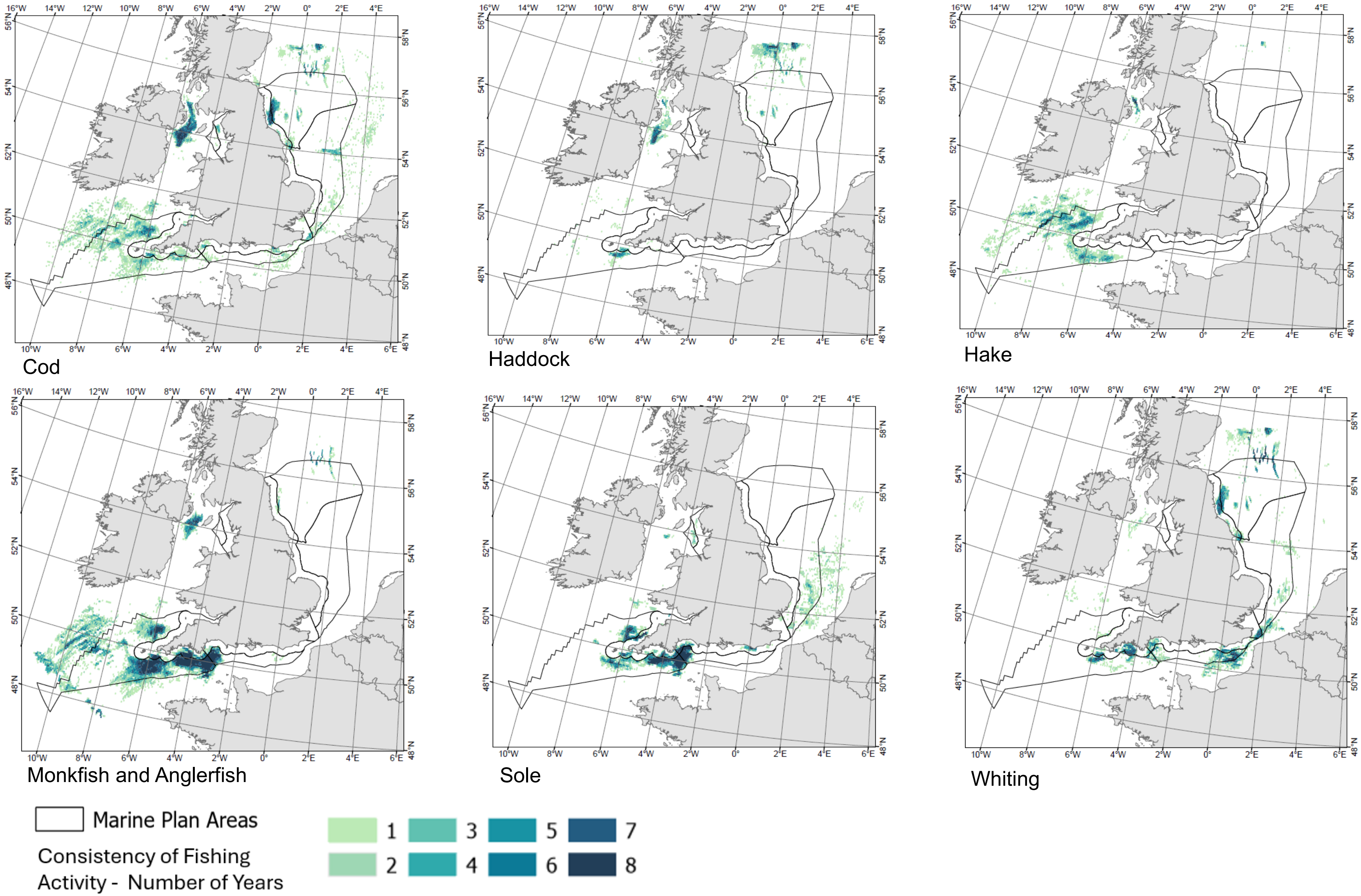
Demersal Trawl
Gillnets and Entangling Nets
Pelagic Trawl
Pots and Traps
Scallop Dredges
Seine Nets
Marine Plan Areas
Consistency of Fishing Activity - Number of Years
1
2
3
4
5
6
7
8

).

Species important areas

Species important areas generally align well with the important areas for their respective gear groupings, as displayed in **Figure 16.** Important areas for cod align with important areas for demersal trawls and gillnets and entangling nets, with well-defined important areas in the north of the Irish Sea and off the northeast of England, with less well-defined important areas covering much of the Celtic Sea, east and west English Channel, as well as some more dispersed important areas throughout the North Sea. Haddock important areas cover a much smaller range, with a well-defined important area off the southwest of Cornwall, in the north of the Irish Sea, and the largest important area being located off the east coast of Scotland. Important areas for hake are almost exclusively in the Celtic Sea, extending into the western English Channel, with the exception of a well-defined important area in the North Channel between Northern Ireland and Scotland. Monkfish and anglerfish share similar important areas to those of hake, with much of the Celtic Sea being important, as very strongly defined important areas off the north coast of Cornwall, south coast of Cornwall and Devon, and in the north of the Irish Sea. Important areas for sole are mainly concentrated around Cornwall and Devon, however there are some dispersed important areas in the south of the North Sea. Whiting's most consistently used important areas are in the east and west of the English Channel and in the northeast of England, with other less well-defined important areas elsewhere in the North Sea, the Celtic Sea and Irish Sea.

Figure 16. [Next Page] "Important areas" for UK 12-metre and over vessels 2016-2023 using the weight metric across 6 target demersal fish species: cod (top left), haddock (top centre), hake (top right), monkfish and anglerfish (bottom left), sole (bottom centre), and whiting (bottom right).


Cod
Haddock
Hake
Monkfish and Anglerfish
Sole
Whiting
Marine Plan Areas
Consistency of Fishing Activity - Number of Years
1
2
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4
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Important areas for both herring and mackerel closely align with one another and with the important areas for pelagic trawlers (**Figure 17**). Neither species had consistent core areas for all eight years of the time series in any c-squares, with herring only having a maximum of six core areas in a single c-square, see **Table 15** and **Table 16** in Annex 3 for area calculations. Important areas for both species are in the east of the English Channel, in the north of the Irish Sea, and with some dispersed areas in the North Sea.

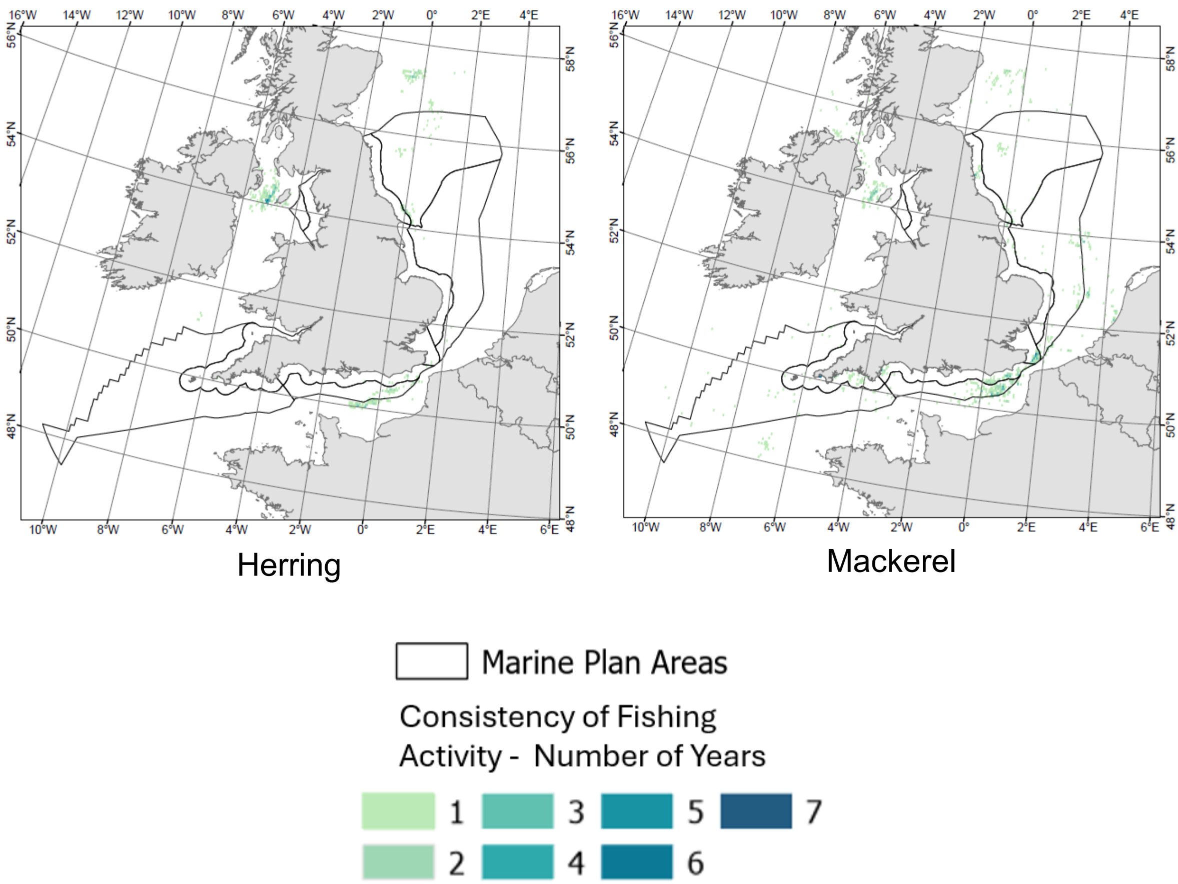


Figure 17. "Important areas" for UK 12-metre and over vessels 2016-2023 using the weight metric across 2 target pelagic fish species: herring (left) and mackerel (right).

Figure 18 shows that important areas for nephrops are well defined, with four distinct areas being core areas for most years of the time series, these being in the north of the Irish Sea, off the northeast of England, in the Firth of Forth, and around the Isle of Arran. There are also important areas which are only core area for a few years in the North Sea and Celtic Sea. Important areas for scallops closely align with important areas for scallop dredges, with multiple important areas in the east and west of the English Channel, north of Flamborough Head, and in the north of the Irish Sea around the Isle of Man.

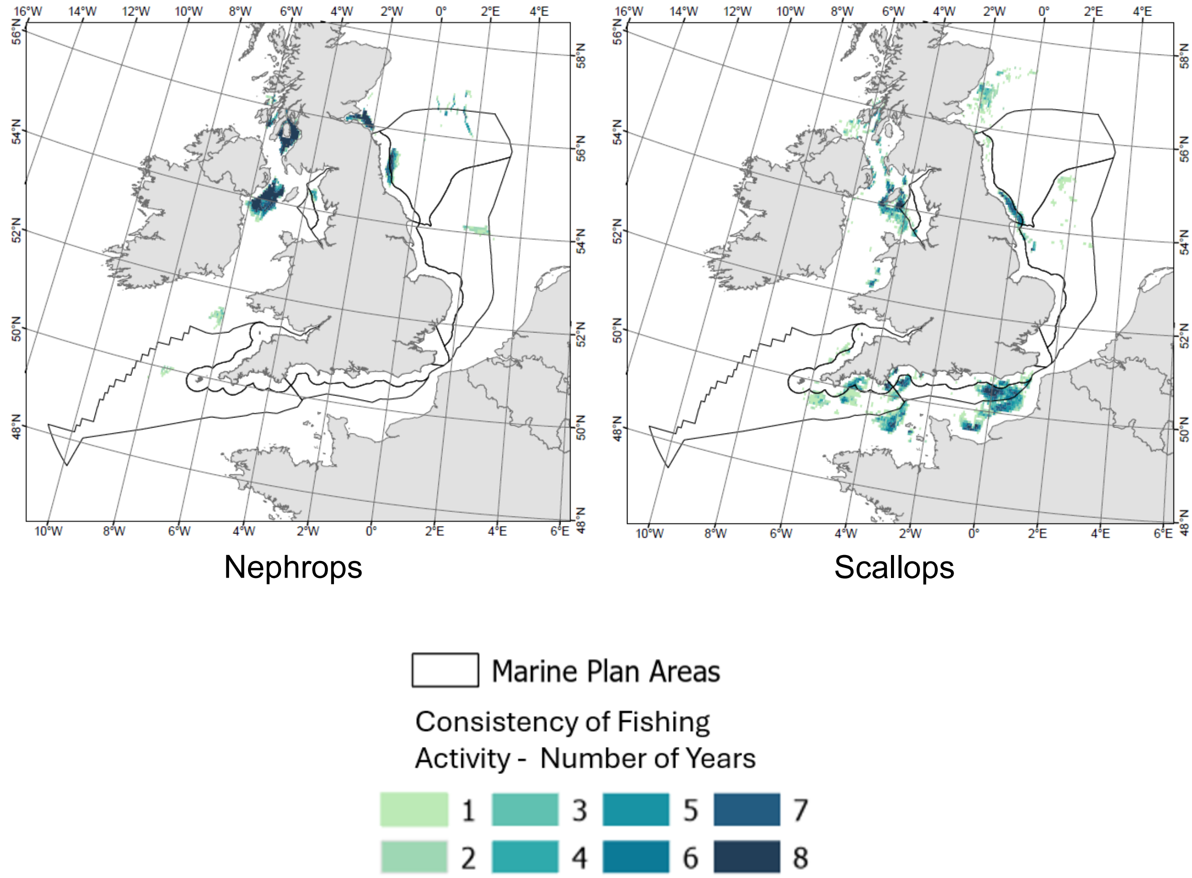


Figure 18. “Important areas” for UK 12-metre and over vessels 2016-2023 using the weight metric across 2 target dredged/trawled demersal invertebrate species: nephrops (left) and scallops (right).

Important areas for crab landings overlap many of the important areas for pots and traps, though not all (**Figure 19**). Important areas for crab landings are moderately well-defined, with some core areas being consistently landed from over the whole time series in the west of the English Channel, near the inshore area 12nm boundary, and off the east coast of England.

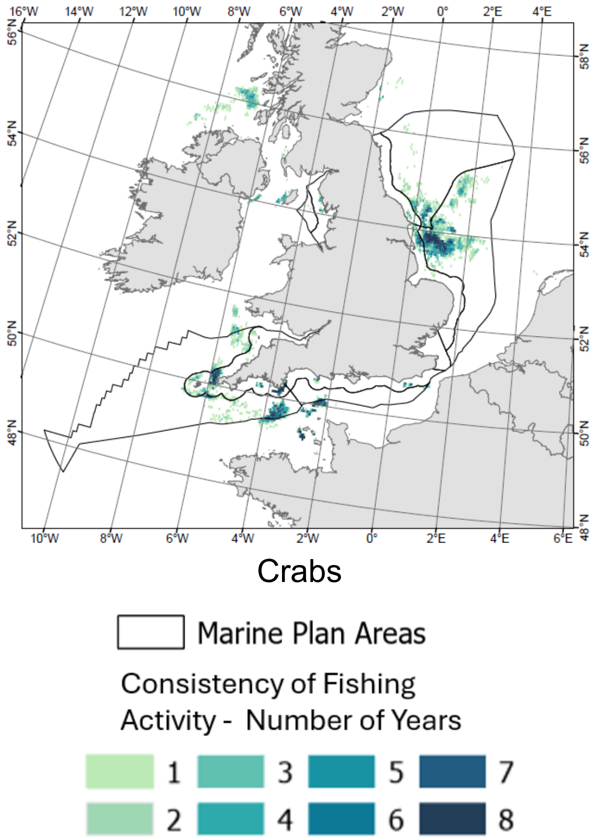


Figure 19. "Important areas" for UK 12-metre and over vessels 2016-2023 using the weight metric for crabs.

Non-UK Important Areas

As shown in **Figure 20** important areas for the non-UK fleet are mainly concentrated in the south, with most of the south of the North Sea, east and west of the English Channel, and Celtic Sea being important. There are also further scattered important areas in the Irish Sea and elsewhere further north in the North Sea. There appears to be a clear boundary in important areas at the EEZ in the southwest, however this is most likely explained by the requirement for VMS ping data to be shared with the UK when within the EEZ, resulting in a disparity in data coverage within the EEZ and within the 100km buffer zone.

Important areas for non-UK fleets fishing within, and within 100km of, the UK waters again vary by gear grouping, as shown by **Figure 21**. Demersal trawls important areas most closely resemble the all gears important areas, with the only significant difference being a reduction in important area extent north of the EEZ in the Celtic Sea, this is likely due to demersal trawls making up the greatest proportion of non-UK fishing effort, at approximately 70.52% of all non-UK fishing within the study area

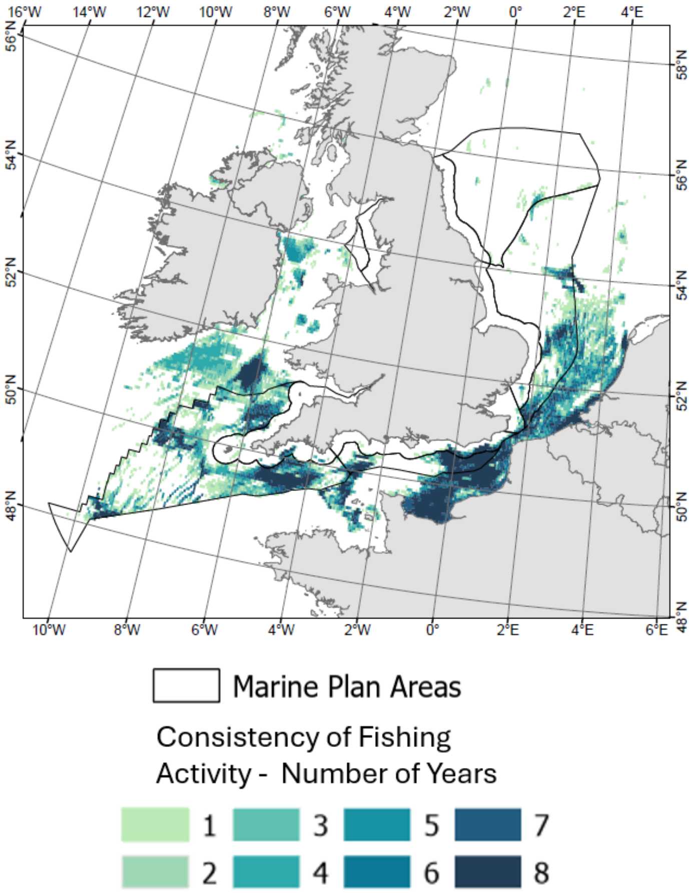
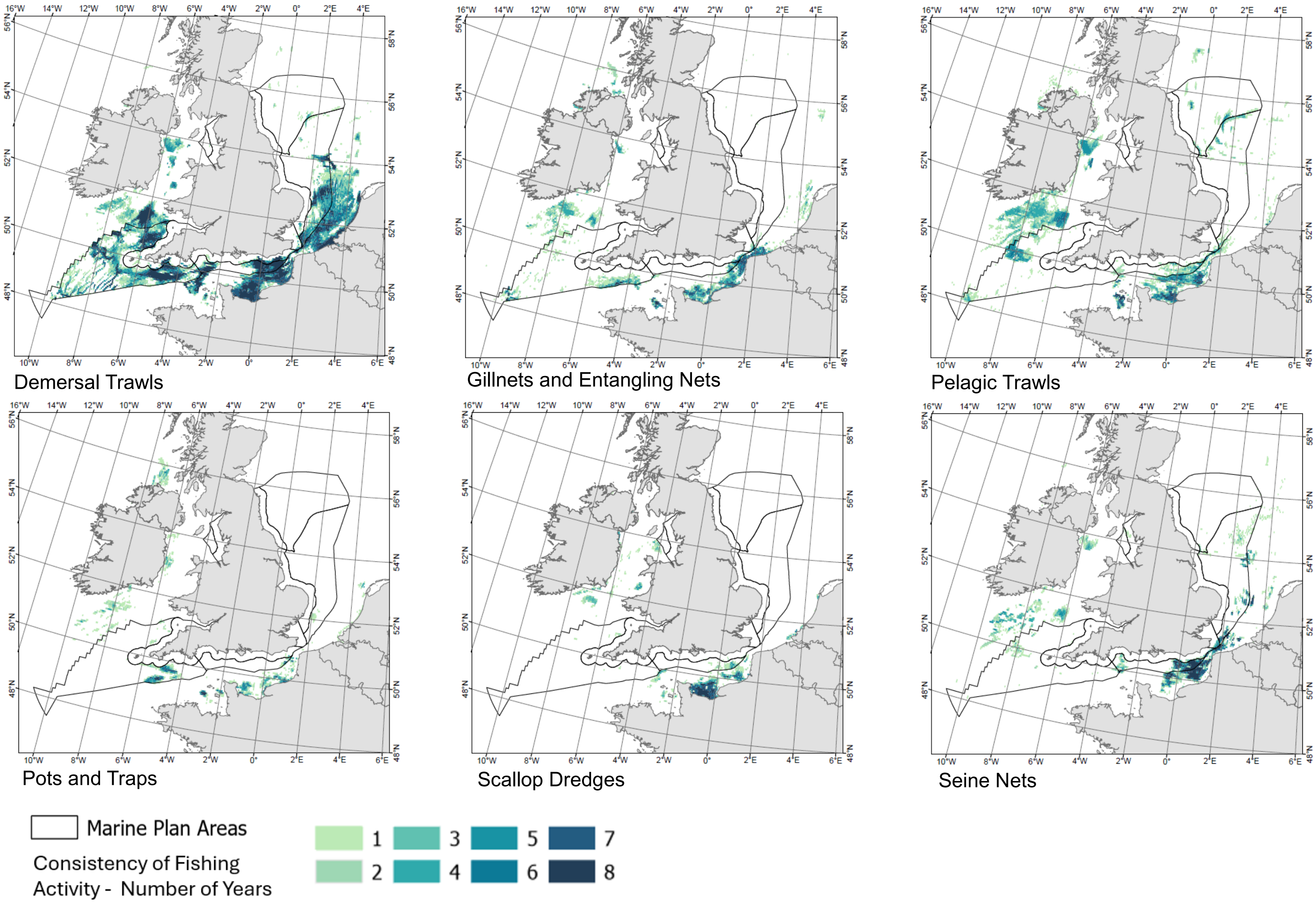


Figure 20. "Important areas" for the non-UK fleet 2016-2023 using the effort (hours) metric for all gears combined.

Gillnets and entangling nets important areas are concentrated close to the French coastline in the west and middle of the English Channel, with additional less consistently used important areas in the east of the English Channel, Celtic Sea, Irish Sea, north of Northern Ireland, and in the North Sea. Important area for non-UK pelagic trawls are concentrated in the middle and east of the English Channel, the Celtic Sea, and the north of the Irish Sea, with other scattered important areas in the North Sea and north of Northern Ireland. Pots and traps have scattered important areas throughout the English Channel, with additional smaller less consistently used important areas in the Celtic, Irish, and North Seas. Important areas for scallop dredges are mainly concentrated in the east of the English Channel, with a few scattered important areas throughout the Irish Sea. Finally, seine net important areas are again concentrated in the east of the English Channel, with some dispersed important areas in the Celtic, Irish, and North Seas.

Figure 21. [Next page] "Important areas" for the non-UK fleet 2016-2023 using the effort (hours) metric across the 6 gear groupings: demersal trawls (top left), gillnets and entangling nets (top centre), pelagic trawls (top right), pots and traps (bottom left), scallop dredges (bottom centre), and seine nets (bottom right).


Demersal Trawls
Gillnets and Entangling Nets
Pelagic Trawls
Pots and Traps
Scallop Dredges
Seine Nets
Marine Plan Areas
Consistency of Fishing Activity - Number of Years
1
2
3
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5
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7
8

Surrounding nets important areas are dispersed throughout the Celtic Sea, north of the Irish Sea, and North Sea, with no important areas being a core area for more than five years out of the eight-year time series. Important areas for hooks and lines are mainly dispersed throughout the Celtic Sea, however there are also a few consistently used important areas, as well as some important areas in the English Channel in the Baie de la Seine (**Figure 22**).

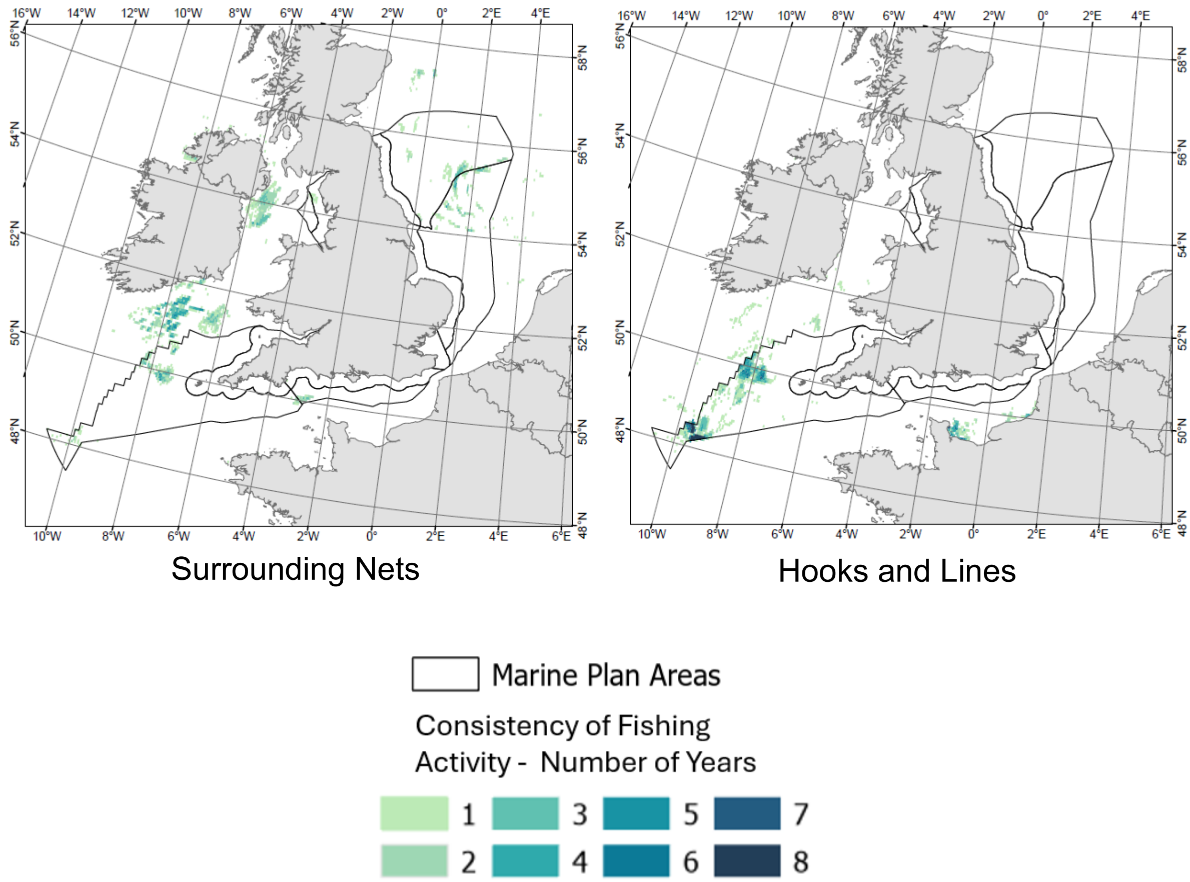


Figure 22. "Important areas" for the non-UK fleet 2016-2023 using the effort (hours) metric across the 2 gear groupings: surrounding nets (left), hooks and lines (right).

Exploration of the Important Areas' Threshold

The 80% threshold was shown to be appropriate for most gear and species groupings, however the validation method showed some species or gear groupings as having a higher value (than the 80% threshold) at which the relationship between proportion of fishing activity and the proportion of space used changed from being disproportionately concentrated in a small area to disproportionately dispersed over a large area. **Table 9** shows the average percentage activity value across each of the different years and metrics for each gear or species grouping, along with their standard deviations.

Table 9. The mean (±1 standard deviation, SD) cumulative fishing activity at which the relationship between proportion of fishing activity and the proportion of space used changed from being disproportionately concentrated in a small area to disproportionately dispersed over a large area, as well as the standard deviation, for each gear and species grouping across all years and metrics.

Grouping	Mean	±1 SD
All gear	81.51	3.43
Demersal trawl	83.64	2.47
Gillnets and entangling nets	78.56	2.13
Hooks and lines	77.73	4.18
Pelagic Trawls	82.34	3.42
Pots and Traps	79.04	0.75
Scallop Dredge	80.41	2.94
Seine Nets	79.23	1.56
Surrounding Nets	89.75	12.30
Cod	80.09	1.65
Haddock	82.56	1.13
Hake	87.41	1.90
Herring	92.33	5.56
Mackerel	82.77	3.84
Monks and Anglers	83.88	1.37
Nephrops	89.43	1.66
Others (species)	77.84	1.43
Sole	84.61	1.83
Whiting	82.06	1.61
Crab	85.29	1.58
Scallops	83.82	2.65

All gear groupings closely confirmed to the 80% threshold apart from surrounding nets which was an outlier with an average value of 89.75%. Surrounding nets also had the greatest variation in values, ranging from 72.46% in 2022 when measured using the effort (kWh) metric up to 111.07% in 2021 when measured using the weight metric. Evidently values greater than 100% highlight a flaw in the method, as 100% is the maximum possible cumulative fishing activity value for any given metric.

All species groupings, except for ‘others’, had slightly higher averages than the 80% threshold, with herring displaying the highest average value, however for both value and weight metrics in 2023 values were above 100% (104.89% and 102.49%, respectively).

The following groupings all also showed years where there was no change in area between two or more deciles of fishing activity: herring and mackerel, hooks and lines, miscellaneous gear, and surrounding nets. **Figure 23** displays an example of this using the cumulative proportion of value as a percentage, plotted by deciles, against the proportion of fished area as a percentage for the hooks and lines gear grouping in 2020.

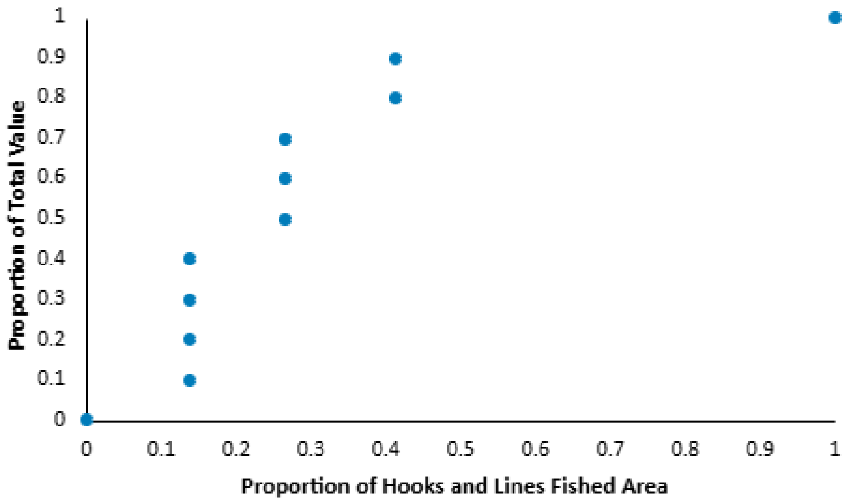


Figure 23. Shows the proportion of the total value plotted against the proportion of the total fished area over which the hooks and lines gear was used 2016-2023.

Figure 24 displays the proportion of total value as a percentage against the proportion of the total fished area as a percentage for nephrops and for 'other' species for each year of the time series. Within the footprint of nephrops fishing, nephrops are shown to have a more linear relationship compared to 'other' species, this would indicate that nephrops display a much more uniform non-random distribution compared to the other' species which display a curvilinear relationship nearing asymptote.

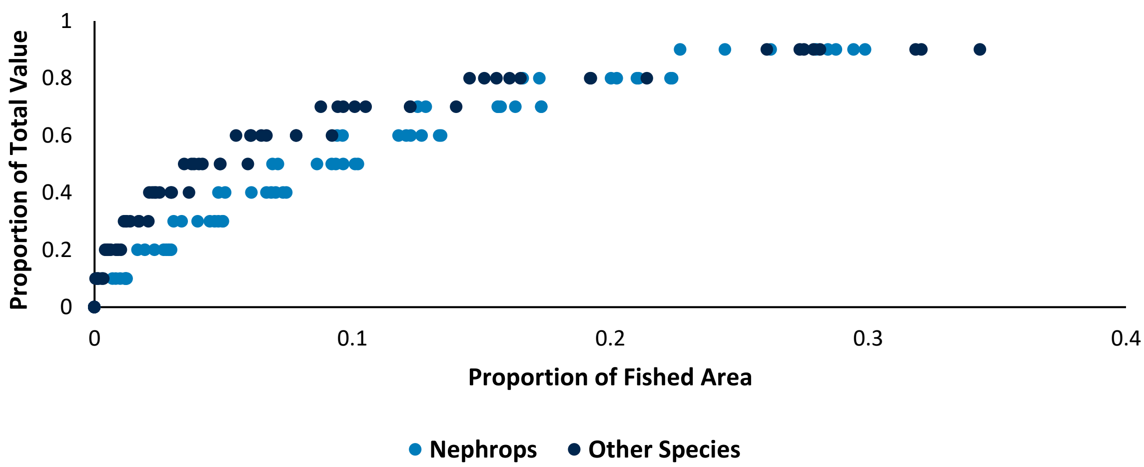


Figure 24. Displays a comparison of the proportion of total value against the proportion of the fished area for nephrops and 'other' species', split into individual years.

Due to the errors identified using this method, further work is required to validate the method used to investigate the 80% threshold, or to develop a more robust method to validate the 80% threshold. This is described in the "further potential for development" section.

Examination of the Change in Important Areas Across the Time Series

The changes to important areas sizes for specific gear types and species were tracked to determine the influence of environment variability on the fishing areas of the UK fishing fleet. For the gear types, in addition to an overview of all gears, one mobile gear (demersal trawls) and one static gear (gillnets and entangling nets) were selected. Similarly, one mobile species (cod) and one static species (scallops) were compared in the species analysis.

Gear Type Comparison

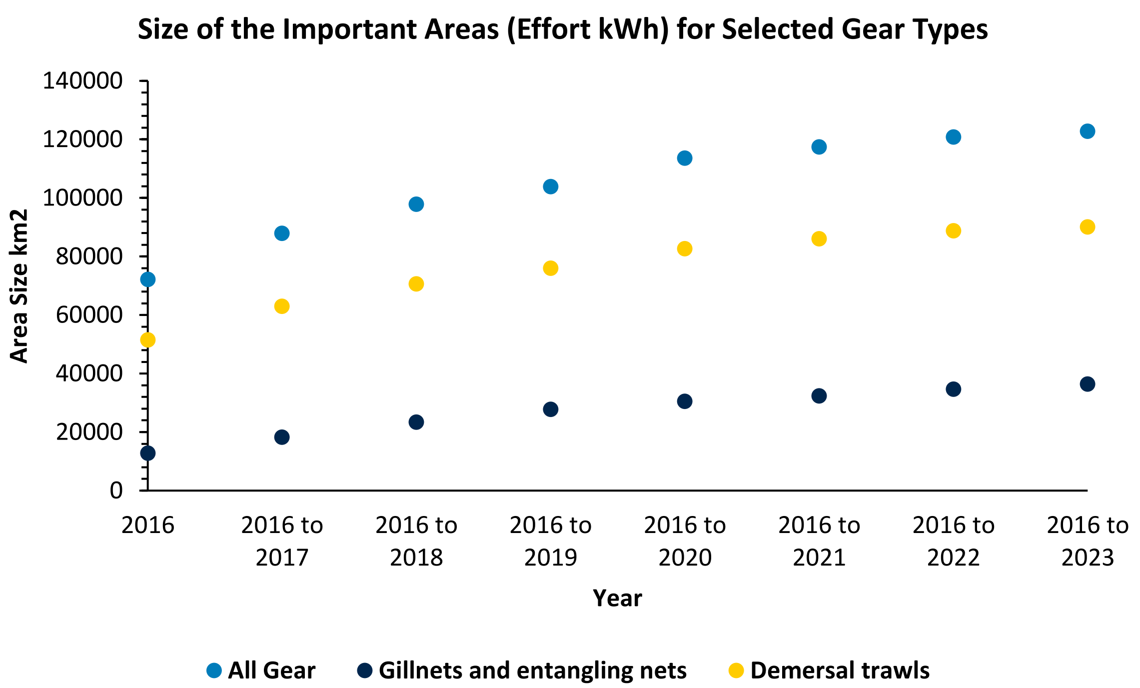


Figure 25. Size of the important areas (km^2) from 2016-2023 for selected gears; all gears, demersal trawls (mobile) and gillnets and entangling nets (static) based on the proportion of effort.

When considering all gears, initially an area of ~72 000km^2 captures the top 80% of effort in 2016. This then leads to a ~16 000km^2 increase of the size of important area in 2017. Following this the increase each year is steadier, until 2020 when the increase per year has a large increase of ~10 000km^2. The rate of increase the continues to fall until by 2023 the size of important area for all gear is ~123 000km^2 (**Figure 25**, **Figure 26**).

A similar pattern is observed in both the mobile and static gears. The size of important area increases each year steadily, until 2020 where there is a larger increase for demersal trawls of ~7 000km^2. The size increase for both demersal trawls and gillnets and entangling nets then stabilises from 2021. The size of important area for demersal trawls from 2016-2023 is ~51000km^2-90000km^2 and for gillnets and entangling nets is ~12000km^2-36000km^2. Furthermore, despite the smaller increase of important area size for the static gears, as a percentage the increase in size each year is greater in static gears (**Figure 26**).

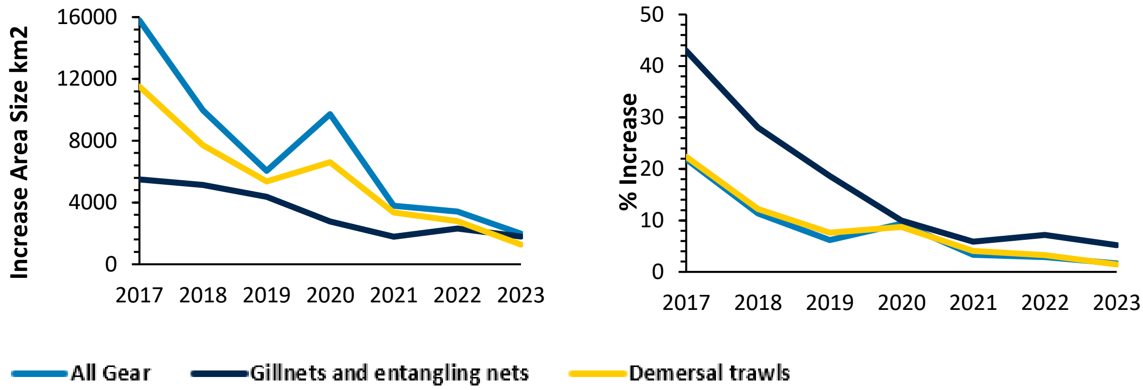


Figure 26. Size increase (left) and percentage increase (right) in the important area size from 2016-2023 for selected gears; all gears (light blue), gillnets and entangling nets (static, dark blue) and demersal trawls (mobile, yellow) based on proportion of effort

Species Comparison

Specific species important fishing areas were also examined against timeseries duration. It is essential to note prior to analysing the changes to species important areas that there are several factors that influence important areas for species but not necessarily for gears. For example, climate change, fisheries closures due to byelaws, and quota changes may affect the distribution of certain species, which may have implications for the important area size and area changes over time.

Similarly to specific gear type comparison, the increase to the important areas for the selected species steadily rises for both cod and scallops each year (**Figure 27**). However, for cod rather than a plateau in the increase of important area size in 2023 there is a large increase of ~3000km^2 in 2022 and ~7000km^2 in 2023 (**Figure 28**).

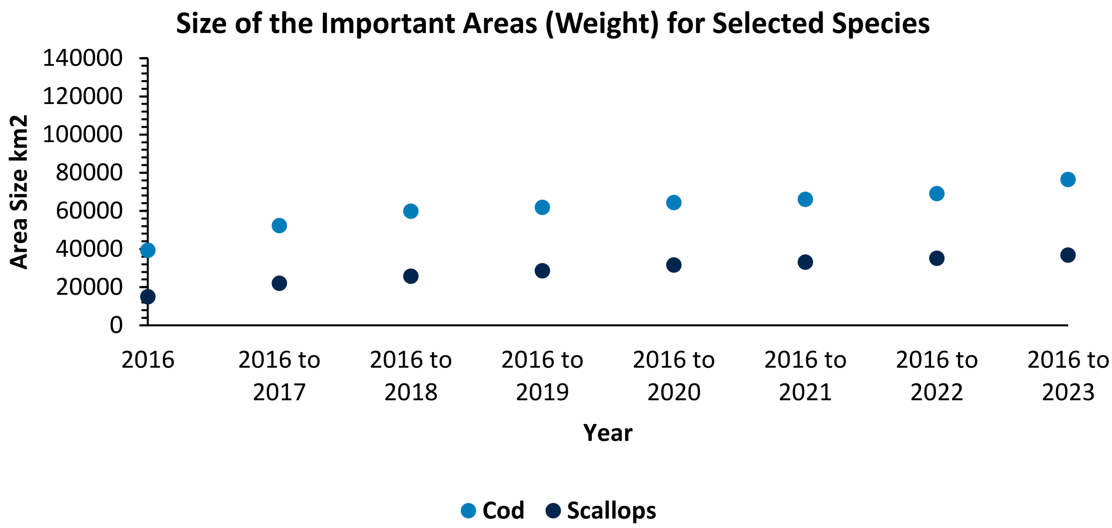


Figure 27. Size of the important areas (km^2) from 2016-2023 for selected species; cod (mobile) and scallops (static) based on the proportion of the total weight.

The size of important areas for cod from 2016-2023 is ~39000km^2-76000km^2 and for scallops is ~15000km^2-36000km^2 (**Figure 27**). Once again, while there is a smaller increase to the static species important area size, the increase is greater for the static species when represented as a percentage (**Figure 28**).

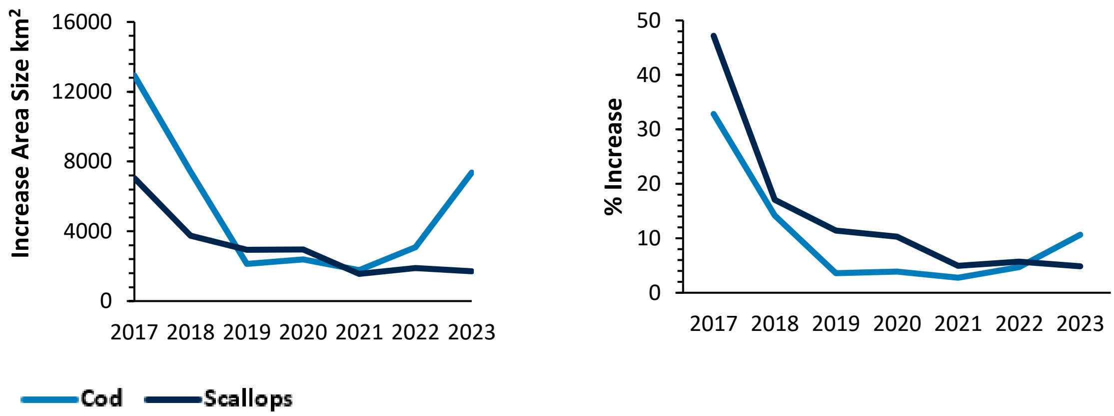


Figure 28. Size increase (left) and percentage increase (right) in the important area size from 2016-2023 for selected species; cod (light blue, mobile) and scallops (dark blue, static) based on proportion of total weight.

Throughout this analysis there is generally a consistent pattern across each permutation, whereby the size increase of the important area steadily increases each year before stabilising 2020-2021. Mobile gear and species cover a wider area than their static counterparts and consequently have larger important areas and size increases per year.

Discussion

Exploring the Results

Important areas by gear grouping and species

All gears demonstrate that the greatest percentage of their important areas are made up of areas which were only a core area for a single year. The percentage contribution gradually decreases as the number of years and areas is a core area increases, indicating that these fisheries operate in different dispersed areas year on year. The exception to this are demersal trawls and pots and traps. For demersal trawls 18.69% of the important areas are made up of areas which are classed as core areas for every single year of the time series and make the second largest area contribution of any year class for this gear type. This would indicate a high degree of consistency in fishing areas year on year for demersal trawls. Similarly, for pots and traps, the important area which are core areas for all 8 years is larger than that of 4, 5, 6, or 7 years, again indicating greater consistency in fishing areas when compared to other gear types, meaning that fishers return to the same areas year-on-year. Data tables and graphs to support this are available in Annex 3.

Similarly to the gear groupings, when looking at the percentage of total area which constitute important areas for each species, per year class, there are variations in the trends for percentage contribution to important area for the various species landings. For cod, haddock, hake, mackerel, scallop and whiting fisheries the largest proportion of their important areas were all made up of areas which were a core area for a single year, with progressively smaller contributions as the number of core areas increased. This shows that between 2016-2023 the important fishing areas for these species varied and was undertaken in dispersed areas each year, highlighting the importance of engagement with the fishing industry in planning proposals to identify the correct areas each season. Crab, monkfish and anglers, nephrops and sole fisheries demonstrated a different trend. For crab, monkfish and anglers and sole the areas which were considered core areas for just one year made up the largest percentage of the important area, however, areas which were core areas for all 8 years of the time series were not the smallest contribution. This indicates greater consistency in catch areas for these species compared to cod, haddock, hake, mackerel, scallop and whiting, and may therefore be more sensitive to displacement, and any produced maps will more accurately reflect the most important areas for these species. Finally, nephrops displayed a significant difference from other species, with the greatest percentage of its important area (34.28%) made up of areas which were classed as core areas for all eight years of the time series. As a result, it is understood that nephrops landings areas are extremely consistent and would be possibly sensitive to displacement. Data tables and graphs to support this are available in Annex 3.

It is more likely that important area sizes and area changes over time for species are more likely to be influenced by factors such as climate variability, than for gears. The influence of climate variation or other factors that influence species distributions were not included in this report but may be responsible for the patterns in important area size and changes seen. Fisheries management measures may also play an important role in the spatial distribution of the important areas, forcing shifts in gear use within areas or causing displacement of gears out of areas, or through quota changes restricting the capture of certain species.

Finally, some important areas for species and gears are present across the value and weight metrics, but not across the effort metric. This includes important areas for pots, traps and crabs, near Flamborough Head and the Wash. This is likely driven by the comparatively low effort (KwH) used for these near-shore fisheries, challenges of representing effort based on VMS for static gear, and the higher landing value of for example the Cromer Crab fishery in the Wash. This highlights the importance of consideration of local, historical and artisanal fisheries which may have high value but do not contribute significantly to national fishing effort.

Fishing Activity by Port

Through mapping the activity of vessels based on the ports they land their catch, the majority of the study area is fished by at least one port, with the exception of the offshore north east marine plan area which has large areas unfished by the UK 12-metre and over fleet. It is also possible to identify hotspots of fishing activity for UK ports (**Figure 10**), where a large number of ports all fish from the same areas. These are strongest around 12nm off the Northumberland coast, off Flamborough head, in the north of the Irish Sea around the Isle of Wight, in the inshore area off both east and west Scotland, and in the east of the English Channel. Much of the west of the English Channel is also used by a large number of ports and there are also other smaller scattered hotspots elsewhere. At the national scale there are generally a lower number of ports landing catch from east England and west Wales. Though, fishing in Welsh waters is mostly made up of under 12-metre vessels using inshore waters, which are not present in this analysis, therefore this result is unlikely to be a true representation of all UK fishing occurring in the area.

It is also possible to analyse vessel activity based on the ports they land their catch at on a regional scale (**Figure 13**). This enables the identification of valuable fishing areas for local smaller ports and coastal communities. For example, the fished areas where catch is landed from at Ipswich and Bembridge are largely separate from the nationally important fishing areas. Understanding where valuable areas for small ports and nationally important fishing areas are located is vital for supporting both communities and large-scale commercial fisheries through regional and national evidence-led plan policy development. These coastal communities may be dependent on fishing for livelihoods, employment and well-being. It is also valuable to understand where several small ports operate in one area as seen around the Isle of Arran (**Figure 10, Table 6**) as impacts to fishing activity in that area can impact several ports and fishing communities.

Changes to Areas Important to Fishing

The analysis of the changes to important area so show a steady increase to the size of important area from 2016 to 2023. During this period the variation in location, despite the increasing size, to important area for all gear and species metrics varies little. This likely indicates that species distribution stayed relatively stable across the time period. It is vital to understand where there are stable patterns of important fishing areas so that deviations from this can be easily tracked and relevant information be fed into management decisions. For example, the all gear and demersal trawl important area increase in 2020 and cod important area increase in 2021-2023 are much larger than in previous years.

Investigating the underlying reasons for the increase in size of important areas to understand how UK 12-metre and over vessels may continue to adapt future activity and to establish effective evidence led marine plan policy development. While it is beyond the scope of the data in this report to identify the exact mechanisms driving the changes in important areas sizes there are key pieces of legislation that were likely sources of the change to important areas for all gear, demersal gear and cod. Firstly, in 2003 a Cod Recovery Zone (CRZ) was introduced in the UK. The objective of the CRZ is to protect cod stocks through prohibiting fishing activity at spawning sites and increasing the minimum mesh size on trawling nets in areas of the North Sea, Irish Sea and west of Scotland. Following the CRZ, a National Cod Avoidance Plan was released in 2020 to provide additional support for the use of real-time area closures and total allowable catches based on vessel inspections and cod stocks in the North Sea. Typically, UK 12-metre and over vessels will catch cod using demersal trawling gear. With the National Cod Avoidance Plan in 2020 it is possible that traditional areas for using demersal trawls and catching cod were no longer accessible. Therefore, fishers may have moved their efforts elsewhere to catch cod using demersal trawl gear. This could explain the large increases to important areas seen for demersal trawl gear in 2020 and for cod between 2021-2023.

In addition to this, the UK government enacted the Fisheries Act 2020, which may have also influenced the large increase in nationally important fishing areas for all gear in 2020. The Fisheries Act 2020 was introduced to provide a framework of how devolved UK governments could manage UK fisheries following the exit from the European Union. Key features of this act are a greater focus on increasing sustainability of fisheries, creating a requirement for 65% of fish caught in UK waters to be landed at UK ports and mandatory electronic vessel monitoring. However, the Fisheries Act 2020 only became law in November 2020, not leaving much time to impact fishing activity in 2020. Therefore, it is more likely that the changes in important areas to all gear, demersal trawls and cod in 2020 are driven by a combination of National Cod Avoidance Plans and the Fisheries Act in 2020.

A number of other factors may also have influenced the size and distribution of the important areas, including historical changes to species quotas across the time series, changes in activity patterns due to the Covid-19 Pandemic and fisheries exclusion byelaws associated with stock protection and Marine Protected Areas.

Whilst this study uses a sufficiently long enough time series to identify a stable environment and variations to important areas, increasing the time series may also aid future research by allowing for greater data robustness to detect long-term patterns in climate, ocean cycles and species distributions influencing fishing activity.

Furthermore, as the percentage of important area increase is greater for smaller static fisheries it suggests that changes to these fishing areas are proportionally greater than for larger scale mobile fishing. This is important to understand so that management plans are evidence-led and tailored for gear types, species and their important fishing area. Therefore, most benefitting both larger scale commercial operations and smaller fisheries in the community, as well as the marine environments they use.

Comparing important areas at different scales

When processing the data over different spatial extents different important areas emerge, this is demonstrated by **Figure 29** and **Figure 30**, which compare the identified important areas for the entire study, clipped to the south west and north east marine plan areas, against important areas which have been generated by clipping the raw data to the marine plan areas prior to processing. As is shown in **Table 10**, it is possible for the spatial extent of an important area to be either larger or smaller when the data is processed at a more regional level than at a larger scale such as at a national level or, in this case, the scale of the study area.

Figure 29 displays a comparison of the important areas at different scales, using 3 gears in the south west marine plan area as an example. For all gear, the important area at the ‘study area’ scale is larger than that of the ‘marine plan area’ scale. The entire ‘marine plan area’ scale important area is encompassed within the ‘study area’ scale important area. The reason these additional areas are identified as important when looking at the ‘study area’ scale is because the south west has intense demersal fishing activity, relative to the rest of the study area. However, when looking at the ‘plan area’ scale, these same areas have lower fishing intensity relative to the top 80% fishing activity within the plan area, therefore highlighting the importance of understanding the context in which importance is being determined.

Table 10. Comparison between the important area extents 2016-2023 within the south west marine plan area and north east marine plan area when processing the data at a national scale and clipping to the marine plan areas (clipped) versus the processing the raw data at the marine plan area scale (regional).

Gear	South West Regional (km^2)	South West Clipped (km^2)	North East Regional (km^2)	North East Clipped (km^2)
All gear	25519	30026	6493	7108
Demersal trawl	22817	28255	4489	4936
Pelagic trawl	3116	1140	2521	2536
Pots and traps	8472	8226	6459	4005
Surrounding nets	626	631	0	0
Seine nets	2670	885	1836	779
Scallop dredge	8870	6973	1545	1755
Gillnets and entangling nets	22641	22333	0	0

Pelagic trawls conversely have a larger important area extent at the plan area scale, with numerous additional c-squares isolated from the ‘study area’ scale important areas being present. This is because pelagic trawls have lower relative importance in the south west when considered at the ‘study area’ scale. For seine nets again the important area extent at the plan area scale is larger, with a cluster of c-squares, which are not important at a ‘study area’ scale for seine nets, being identified as important appearing towards the boundary with the south marine plan area.

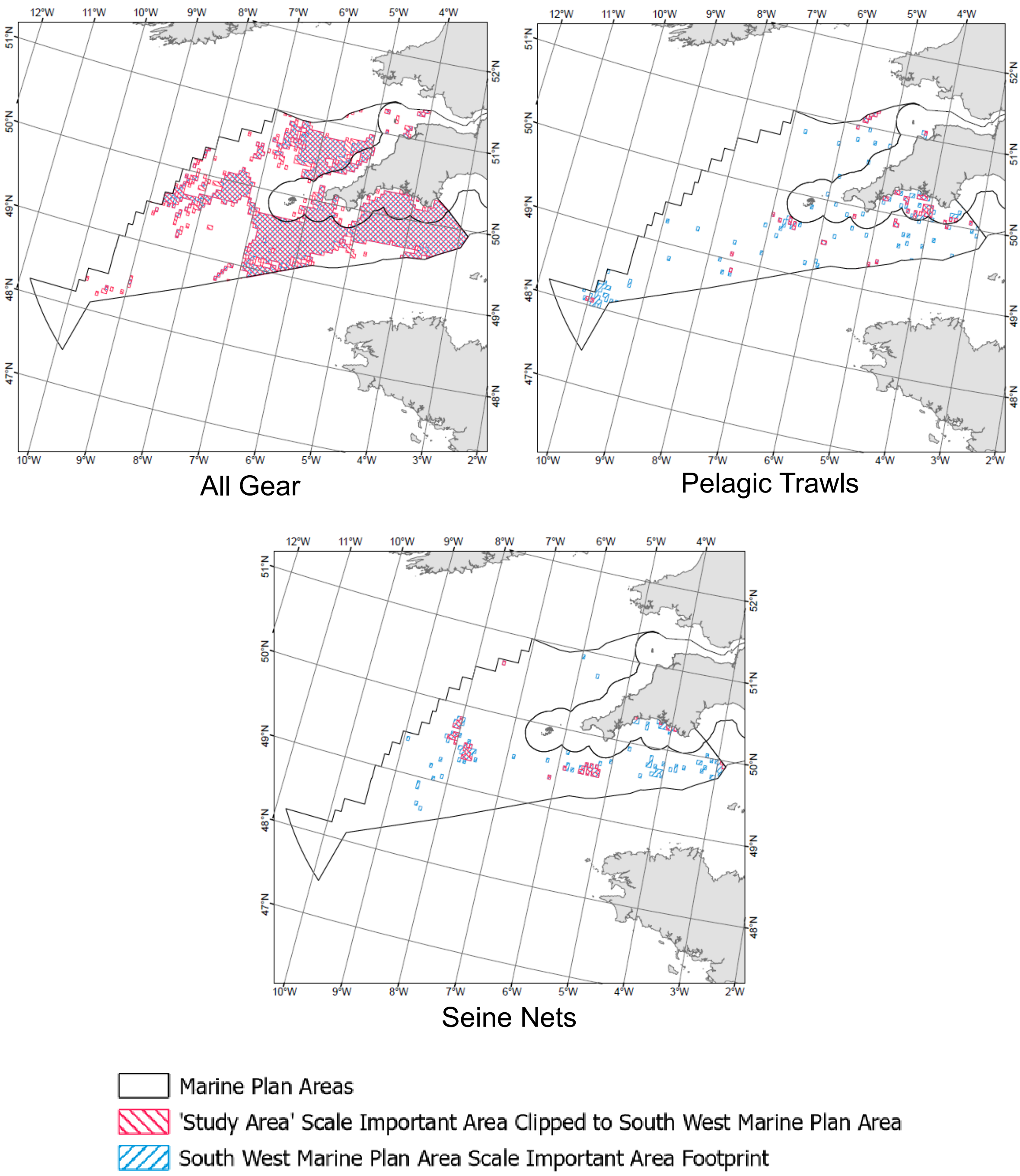


Figure 29. Comparison of the study area (UK) important area footprint 2016-2023 clipped to the south west marine plan area against important areas created when the raw data is clipped to the south west marine plan area prior to data processing (UK 12-metre and over effort (kWh)) for 3 gear groupings: all gear (top left), pelagic trawls (top right), and seine nets (bottom).

Figure 30 again displays a comparison of the important areas at different scales, this time using 2 gears in the north east marine plan areas as an example. Both examples show the north east marine plan areas scale important areas being larger than the 'study area' scale important areas. For pots and traps, the north east scale important areas expand the ‘study area’ scale important areas, as well as identifying additional isolated areas. For seine nets the north east marine plan areas scale important areas identify new areas which aren’t identified as important at the ‘study area’ scale.

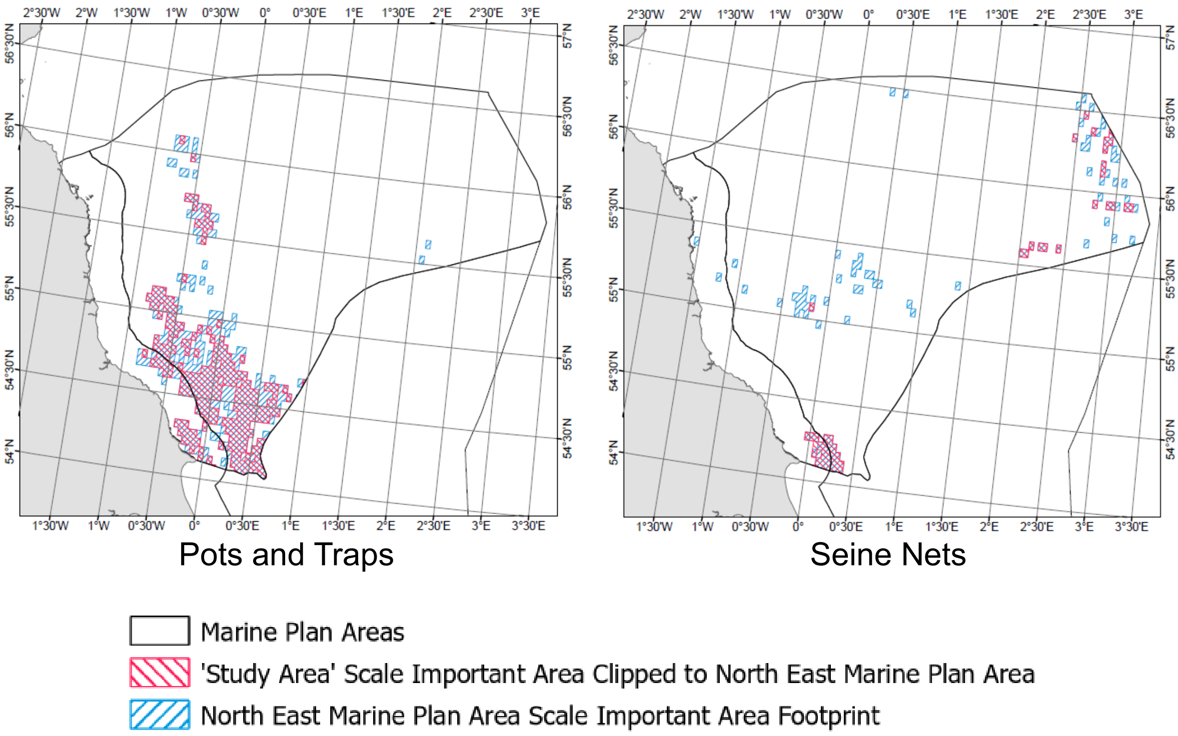


Figure 30. Comparison of the study area important area footprint 2016-2023 clipped to the north east marine plan area against important areas created when the raw data is clipped to the north east marine plan area prior to data processing (UK 12-metre and over effort (kWh)) for 2 gear groupings: pots and traps (left), and seine nets (right).

The ’important areas’ threshold

The method used to validate the important areas threshold indicates that, for the majority of gear and species groupings, the 80% cut-off is appropriate. There is some variability, for example the proportion of fishing activity for nephrops is more heavily concentrated in a relatively small area when compared against other species or gear groupings, resulting in a steeper curve and a higher proportion of fishing activity where the tangent line would equal 1. It may be valuable to consider whether circumstances such as this would warrant a change in threshold value for that species.

It was also seen that in species or gear groupings where there is a sufficiently small spatial extents the method did not perform well, with individual c-squares being able to contribute multiple deciles worth of fishing activity. This resulted in no change in gradient between deciles meaning that it was then not possible to fit a trendline and calculate for the point at which the tangent line gradient was 1. Further, in surrounding nets and herring (both groupings which, when split by year, had very small spatial extents) there were years where the proportion of fishing activity at which the tangent line gradient was 1 exceeded 100%. Evidently this would not be possible and highlights a flaw in the method when used on a dataset with a small spatial extent.

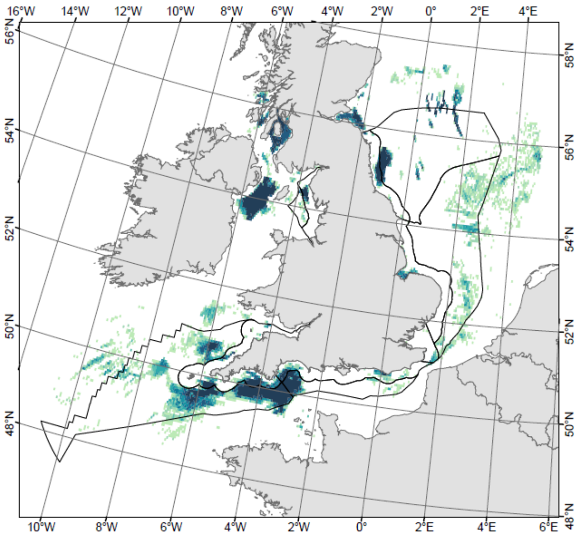
UK and Non-UK ’important areas’ consistency

When comparing the consistency of important areas for six gear groupings of the UK and non-UK fleets there are important patterns to understand (**Figure 31**). Gillnets and entangling nets activity for UK fleets mostly occurs in south west England, where there is a strong consistency in the use of these areas each year, whereas the non-UK fleet tend to deploy gillnets and entangling nets in the southern region of the English Channel. This perhaps indicates it is not very valuable or cost-effective for the non-UK fleet to travel so far across the UK to deploy gillnets and entangling nets for any of their target species. For scallop fishing the English Channel remains consistently important for the non-UK fleet, closer to the north French coastline. The UK fleets also use the English Channel consistently, yet the main activity occurs closer to the southern English coast. The proximity of scallop gear to the UK coast for the UK fleet and French coast for the non-UK fleet demonstrates the application of this gear in nearby coastal waters. There are high abundances of scallops in the English Channel meaning the non-UK fleet do not need to travel further up the UK coastline to Wales and Scotland to target these species.

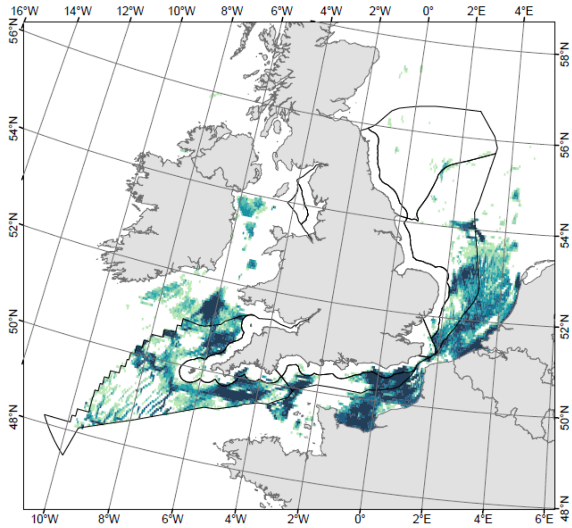
Pots and traps are used in very consistent areas around the UK coastline by UK fishers. This is perhaps due to the low cost and high accessibility of pots and traps, along with the abundance of target species around the coast. The accessibility and wide availability of target species may also explain why non-UK fishers show much less pot and trap activity around the UK. There may be greater use of this technique in their country’s coastal waters and less need to travel to the UK to undertake this activity.

Seine nets share a consistent common important area for both UK and non-UK fleets in south east England. This indicates that these waters are productive for this type of gear and the species landed using it. It is valuable for both UK and non-UK fleets to use this area year on year.

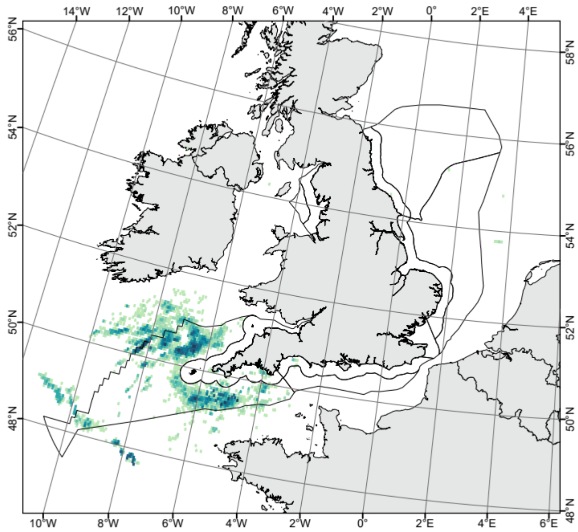
The non-UK demersal and pelagic trawls fleets consistently use a greater size of important area year on year in the UK, than the UK fleet, possibly indicating different fishing habits and approaches to the UK fleet. Most of this activity is concentrated in the English channel, south west England and south England, closer to neighbouring administrations.



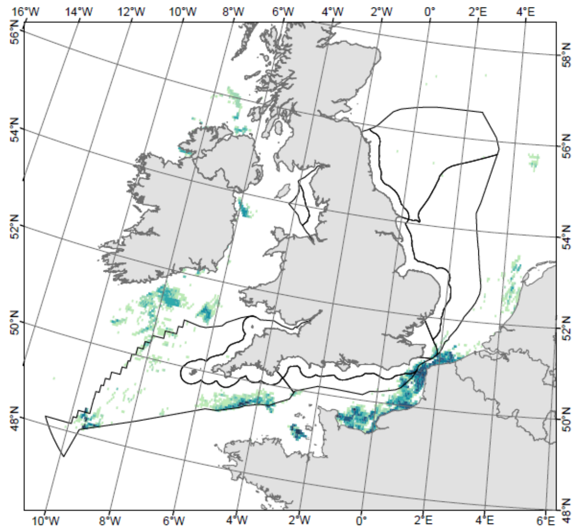
UK Demersal Trawls



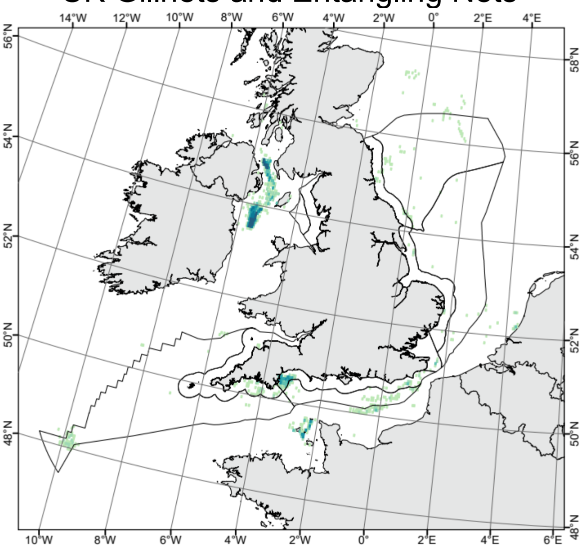
Non-UK Demersal Trawls



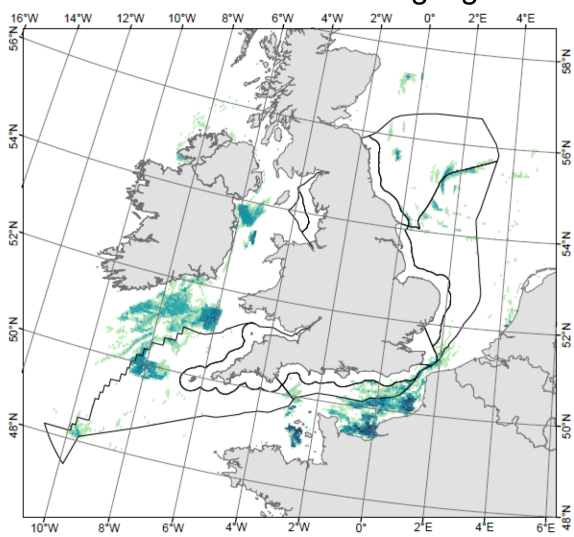
UK Gillnets and Entangling Nets



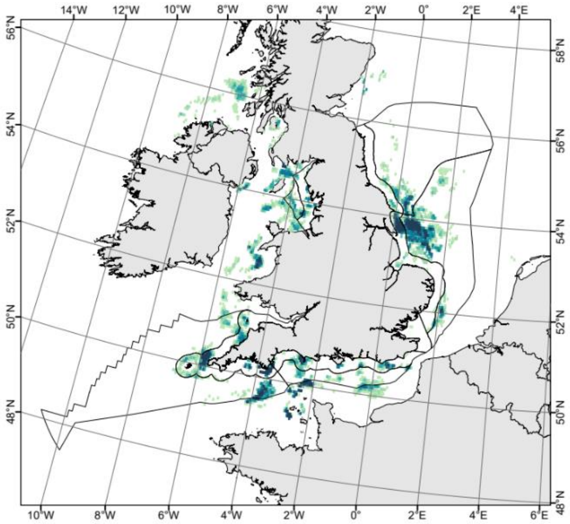
Non-UK Gillnets and Entangling Nets



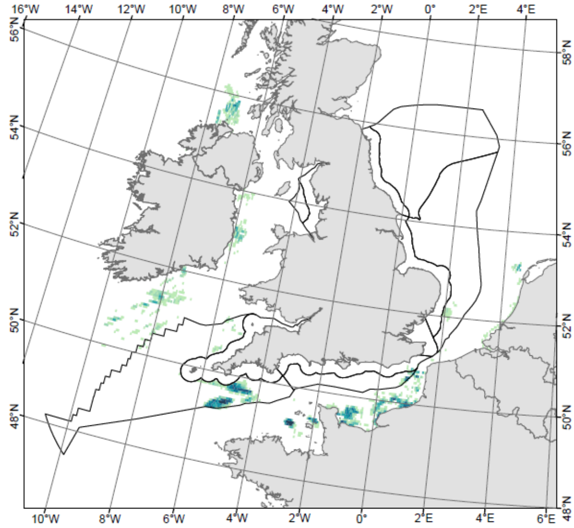
UK Pelagic Trawls



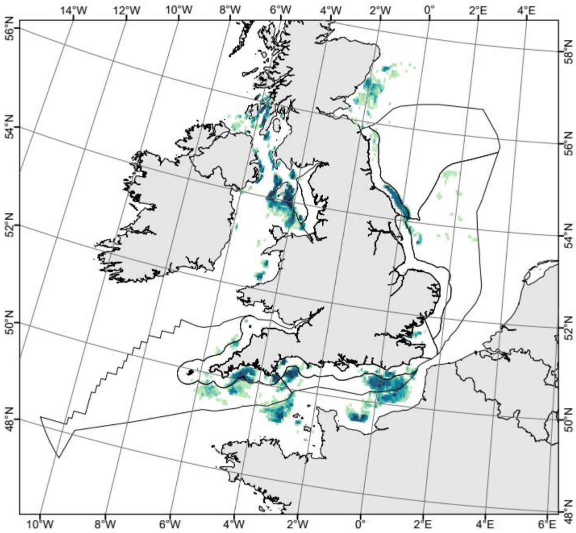
Non-UK Pelagic Trawls



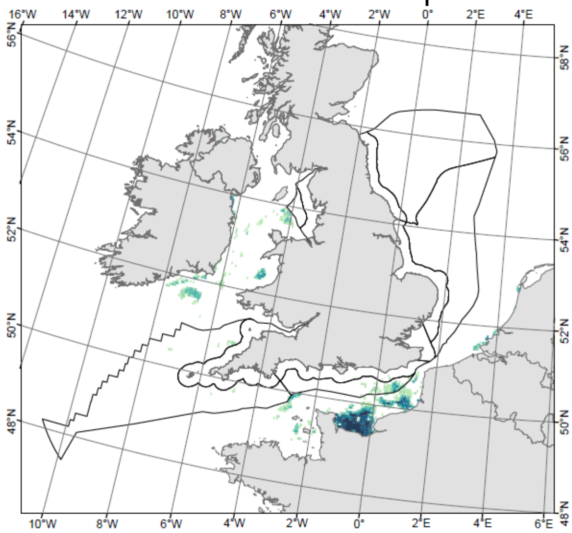
UK Pots and Traps



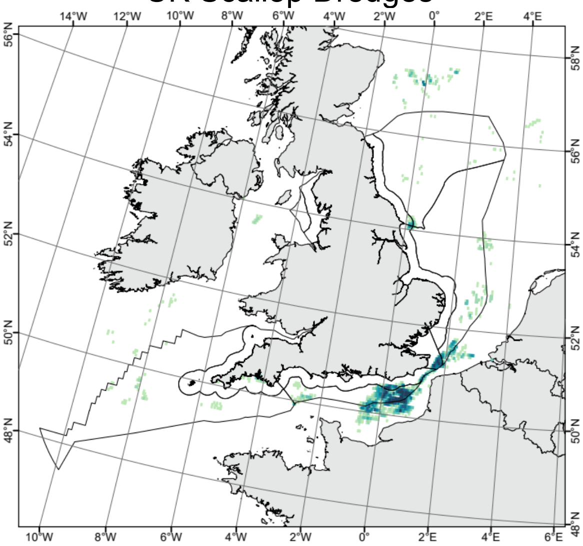
Non-UK Pots and Traps



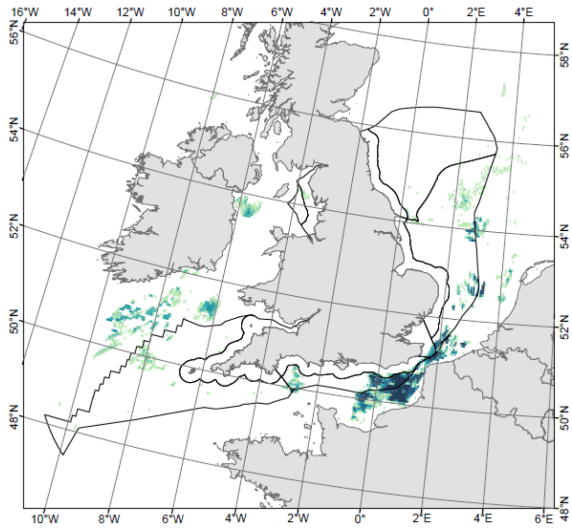
UK Scallop Dredges



Non-UK Scallop Dredges



UK Seine Nets



Non-UK Seine Nets

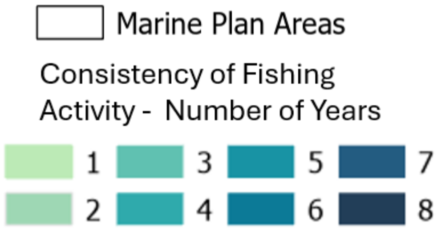


Figure 31. [Previous pages] "Important areas" for the UK (left) and non-UK fleet (right) 2016 – 2023 using the effort (hours) metric across the 6 gear groupings: demersal trawls (first row), gillnets and entangling nets (second row), pelagic trawls (third row), pots and traps (fourth row), scallop dredges (fifth row), and seine nets (sixth row).

Comparison with other fisheries mapping projects

To contextualise and evaluate the robustness of the fisheries mapping undertaken in this project, it is valuable to compare the MMO's outputs with those from other internal and external fisheries mapping projects. These include MMO-led initiatives such as MMO1382 and MMO1384, as well as externally conducted studies like the FiSMaDiM project. Each of these sources has adopted distinct methodologies, data inputs, and objectives, which contribute to a more comprehensive understanding of fishing activity across different fleet segments and geographic scales.

By examining these alternative datasets, it becomes possible to identify areas of convergence and divergence in mapped fishing grounds and to assess how different methodological choices—such as data sources, resolution, and fleet coverage—influence the representation of fishing effort and economic sensitivity. This comparative approach supports a more nuanced interpretation of the spatial data and highlights key considerations for future evidence development, especially regarding the inclusion of smaller inshore vessels and the potential need for improved tracking technologies.

MMO1382

In 2024, the Marine Management Organisation (MMO) published evidence project [MMO1382: Sensitivity of the under 12-metre fishing fleet to offshore wind development in the East Marine Plan areas](). The objective of this project was to assess the spatial and fishery-specific sensitivity of the UK under 12-metre fleet to all stages of offshore wind farm (OWF) development within the east marine plan areas.

As part of the study, participatory mapping was undertaken to identify key fishing grounds used by the UK under 12-metre fleet. **Figure 32** illustrates the comparison between the fishing grounds identified for UK under 12-metre vessels in MMO1382 and the important areas delineated through the current fisheries mapping, which is based on UK 12-metre and over vessel activity. This comparison highlights spatial overlaps and distinctions in fishing activity between the two fleet segments. Across all four gear groups, there are proportionally extensive areas identified in MMO1382 that are not captured within the UK 12-metre and over important areas. This discrepancy is particularly pronounced for pots and traps and demersal trawl fisheries.

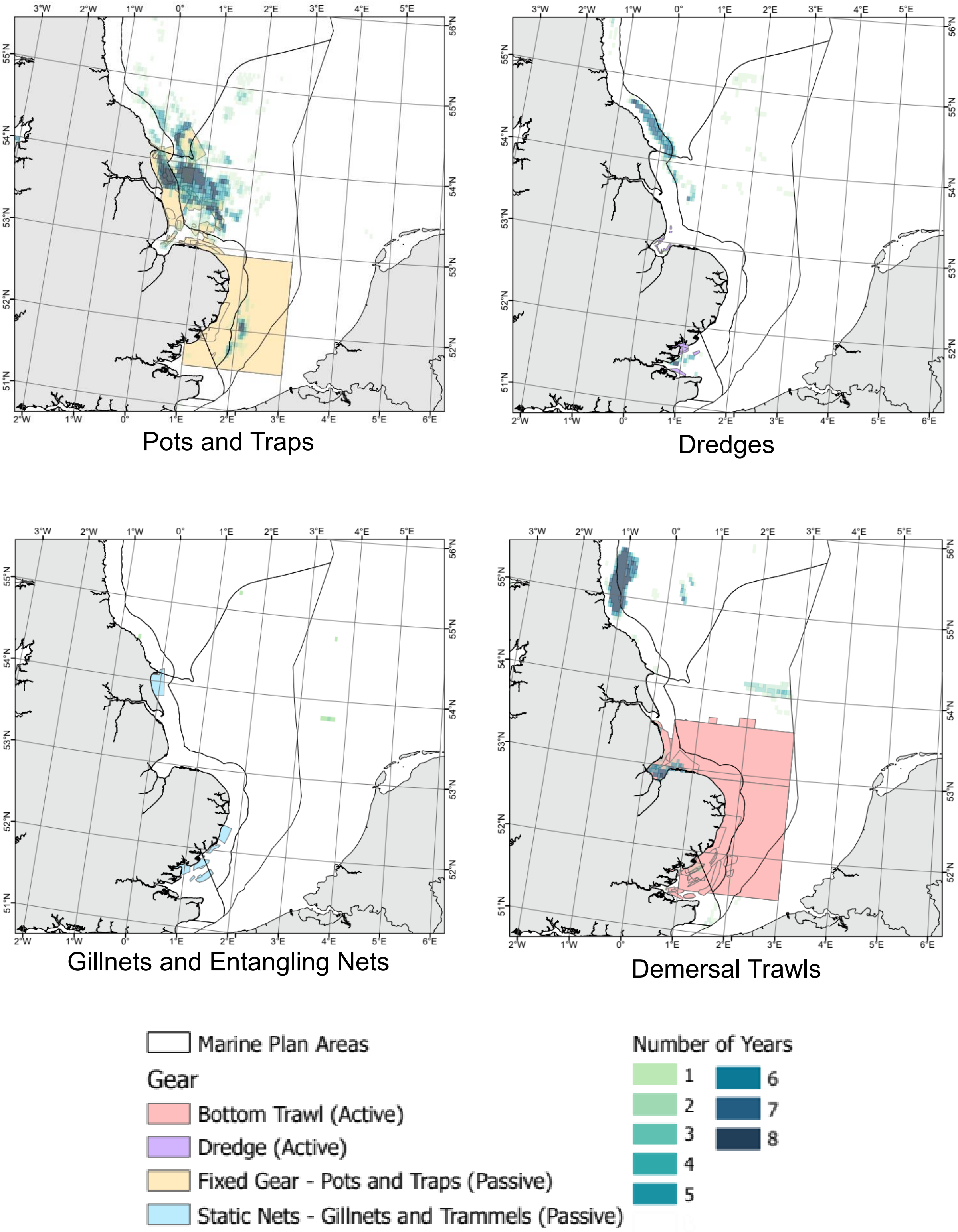


Figure 32. Overlays of "Important areas" for UK 12-metre and over vessels 2016-2023 using the effort (hours) metric and the spatial distribution of fishing grounds for UK under 12-metre vessels identified from MMO1382, by gear group: pots and traps (top left), dredges (top right), gillnets and entangling nets (bottom left) and demersal trawl (bottom right).

For vessels under 12-metres in length, MMO1384: Social and Economic Impact Assessments for Commercial Fisheries Management Decisions advises that "engagement with the vessels in the area should be undertaken, to understand their fishing patterns, use of the area in question in the context of the broader ICES rectangle, and the impact it might have." This approach is directly aligned with the methodology used in MMO1382, which engaged with local fishers to gather qualitative insights into spatial fishing patterns and area usage specific to the UK under 12-metre fleet.

This divergence strongly suggests that fisheries mapping based solely on UK 12-metre and over vessels does not adequately represent the spatial extent or significance of UK under 12-metre fleet activity. Given that the MMO1382 data for the UK under 12-metre fleet was obtained through fisher interviews rather than high-resolution tracking data such as VMS, the findings underscore the need for more robust and accurate spatial data—such as from iVMS or other tracking technologies—to effectively characterise the activities of the UK under 12-metre fleet.

MMO vs FiSMaDiM comparison

Gear groups used through this work were aligned with those of the FiSMaDiM project to allow for comparability. The aim of the FiSMaDiM project was to understand the economic sensitivity of fishing grounds as to avoid conflict with the developing offshore wind sector. This was achieved by identifying the spatial distribution of recent fishing activity of UK vessels and developed a fisheries sensitivity index identifying high and low conflict areas. As part of this work, maps were produced to show fishing effort (hours) split by gear grouping.

The data used for FiSMaDiM was an augmentation of VMS and AIS data for higher resolution maps, which involved a large amount of resource intensive data cleaning and matching, the processes for which are detailed in the report, 'A workflow for standardizing the analysis of highly resolved vessel tracking data'. The project also created six indicators to capture the economic importance of fishing activity at each location. These indicators were developed in consultation with the fishing industry, government and offshore wind stakeholders. From these indicators, two separate Fisheries Sensitivity Indices were created to measure the economic importance of the area to the fishing industry.

As with the MMO Important areas work, there are some caveats associated with FiSMaDiM. VMS is only compulsory on UK vessels 12-metres in length or longer, and AIS only on vessels greater than 15-metres in length, with both systems voluntary on smaller vessels. The data may therefore underrepresent smaller vessels below those thresholds, evidenced by the dataset used only including 17% of UK-flagged vessels, which aligns roughly with the number of UK-flagged vessels 12-metres or more in length. FiSMaDiM also includes a component of non-UK vessels within the same dataset. Fisheries data, particularly landings, are collected at lower resolutions, which increases uncertainty when applied to high-resolution grids. The data does also not account for past spatial access restrictions – as is the same with the MMO important areas work - so some areas may appear as low intensity due to restrictions as opposed to actual low fishing activity. The data does however provide significant temporal depth with the time series running from 2012-2021, allowing for annual variation.

In comparison, the MMO used data extracted directly from the Cefas GeoFISH spatial database, which required little manual data intervention. GeoFISH combines VMS position with logbook data and automates the calculation of relevant fisheries metrics through spatial apportionment of landings to VMS data. Applying a top 80% threshold for the Important Areas efficiently highlights the most significant areas of activity.

Similar to the FiSMaDiM data, there is limited small-scale representation, having only captured UK 12-metre and over vessels using VMS data, so smaller or non-VMS vessels are only represented in separate data not updated in this report, and non-UK vessels are also covered in a separate dataset. Unlike FiSMaDiM, GeoFISH's methodology is not readily available to the public which provides limited transparency. Though the MMO data and maps created during this project would be easily replicable internally to the MMO, external researchers or consultants may may find replication more difficult.

Figures 33-39 (below) show a comparison between the important areas developed by the MMO and the sum fishing hours metric used in the FiSMaDiM project with non-UK vessels filtered out and for England, Wales and Northern Ireland only, split by gear group.

For pots and traps (**Figure 33**) the areas of higher activity align closely across the two projects, with the MMO Important areas generally highlighted as areas of high activity in the FiSMaDiM dataset, with some exceptions along the south and east coasts where MMO important areas appear to show some specific areas of high importance that are not highlighted in the FiSMaDiM data.

This is a general theme throughout the comparison and across the gear groups, where areas show generally good alignment with the exception of some areas appearing as having slightly more importance in the MMO data. This is well exemplified by seine nets (**Figure 34**) and pelagic trawl (**Figure 39**) where some apparently more higher importance activity areas appear as lower intensity in FiSMaDiM.

Figures 40 and 40 shows which areas within the FiSMaDiM data (cropped to the English Marine Area) are also MMO Important areas for the pots and traps and demersal trawl gear types, and the comparison with these areas to the full MMO important area dataset. Again, good alignment is demonstrated and the majority of sites are accounted for in both datasets.

Table 11 shows a detailed analysis of the percentage overlap between the two datasets, showing both the proportion of overlap between MMO and FiSMaDiM data and the proportion of additional sites identified by FiSMaDiM data. This comparison is also drawn from the MMO important areas data, and as such includes the 80% slice. Further validation or movement of this slice may affect the % overlap.

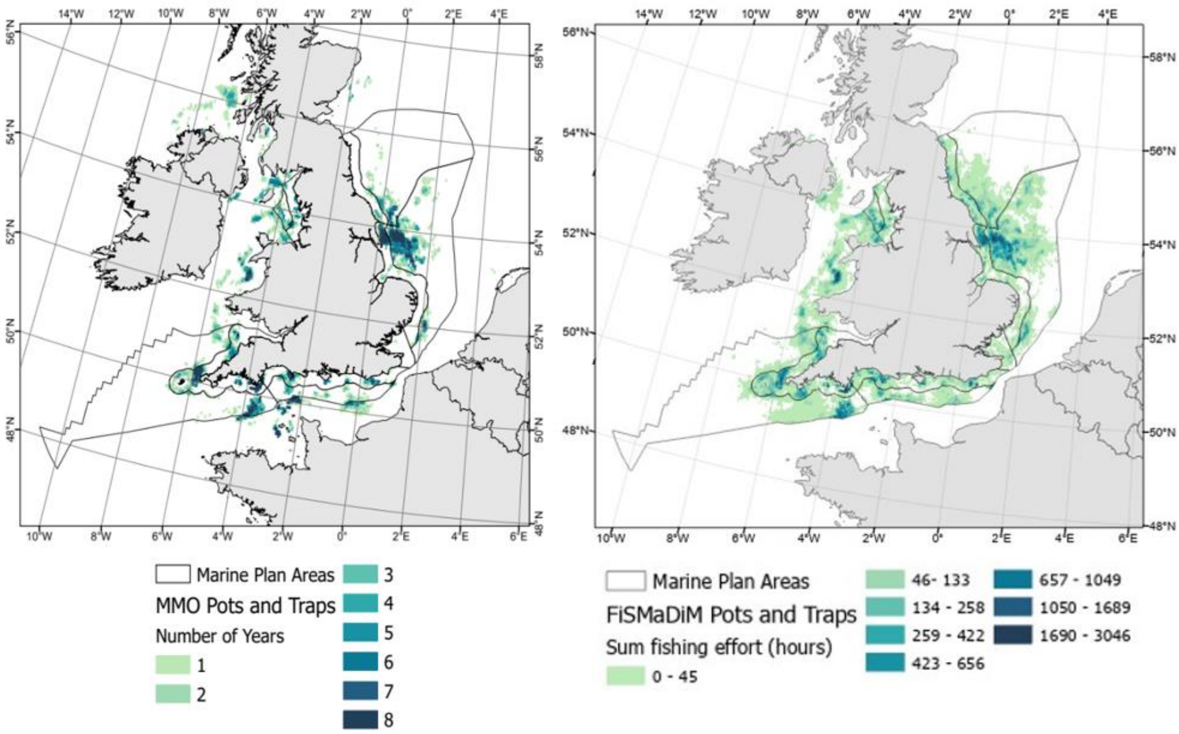


Figure 33. Comparison of MMO important areas for UK 12-metre and over vessels 2016-2023 for pots and traps (left) vs FiSMaDiM sum fishing hours for pots and traps (right).

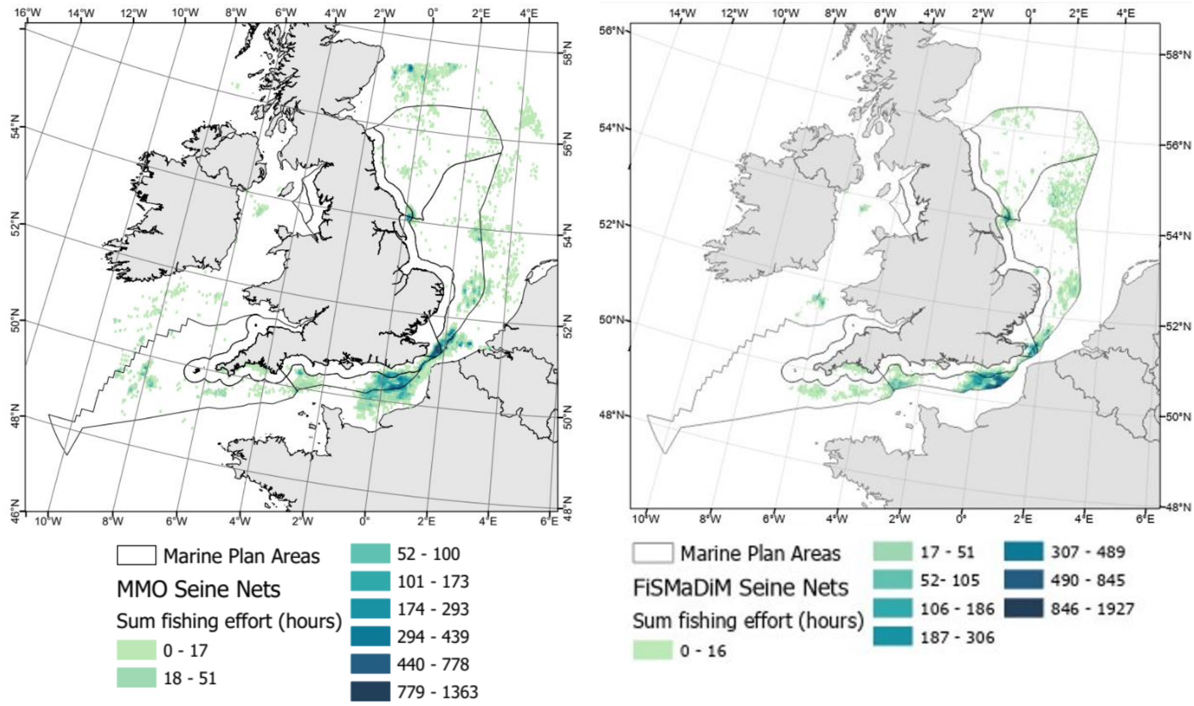


Figure 34. Comparison of MMO important areas for UK 12-metre and over vessels 2016-2023 for seine nets (left) vs FiSMaDiM sum fishing hours for seine nets (right).

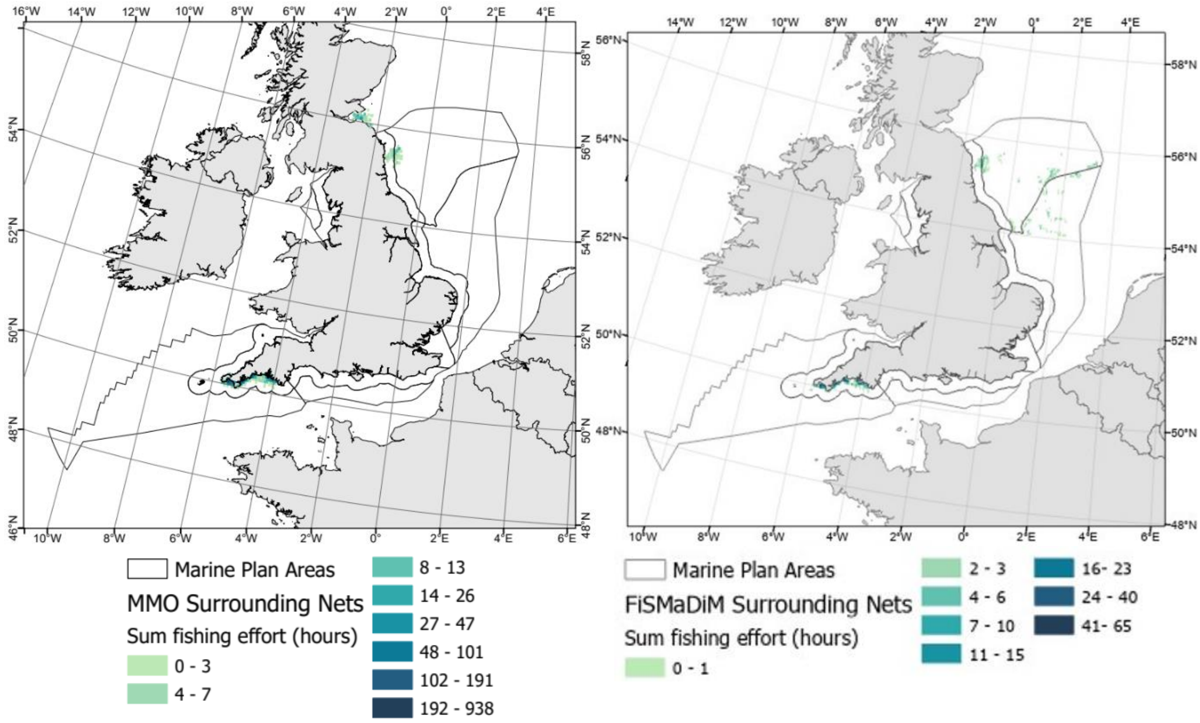


Figure 35. Comparison of MMO important areas for UK 12-metre and over vessels 2016-2023 for surrounding nets (left) vs FiSMaDiM sum fishing hours for surrounding nets (right).

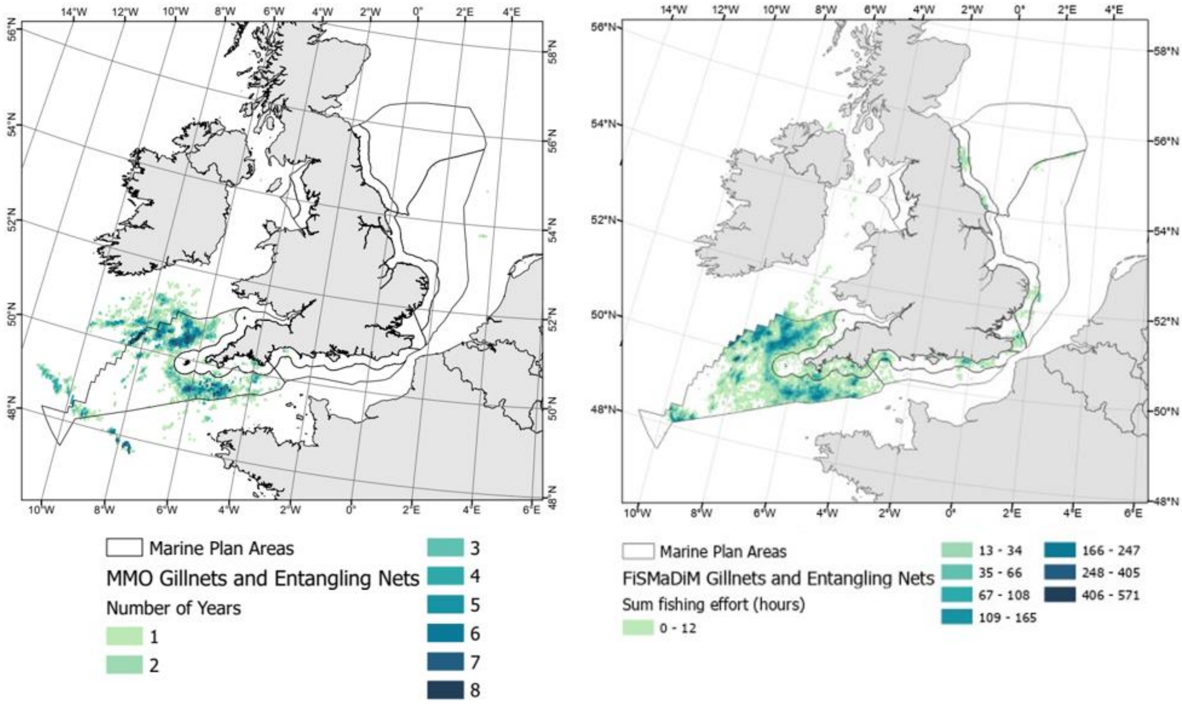


Figure 36. Comparison of MMO important areas for UK 12-metre and over vessels 2016-2023 for gillnets and entangling nets (left) vs FiSMaDiM sum fishing hours for gillnets and entangling nets (right).

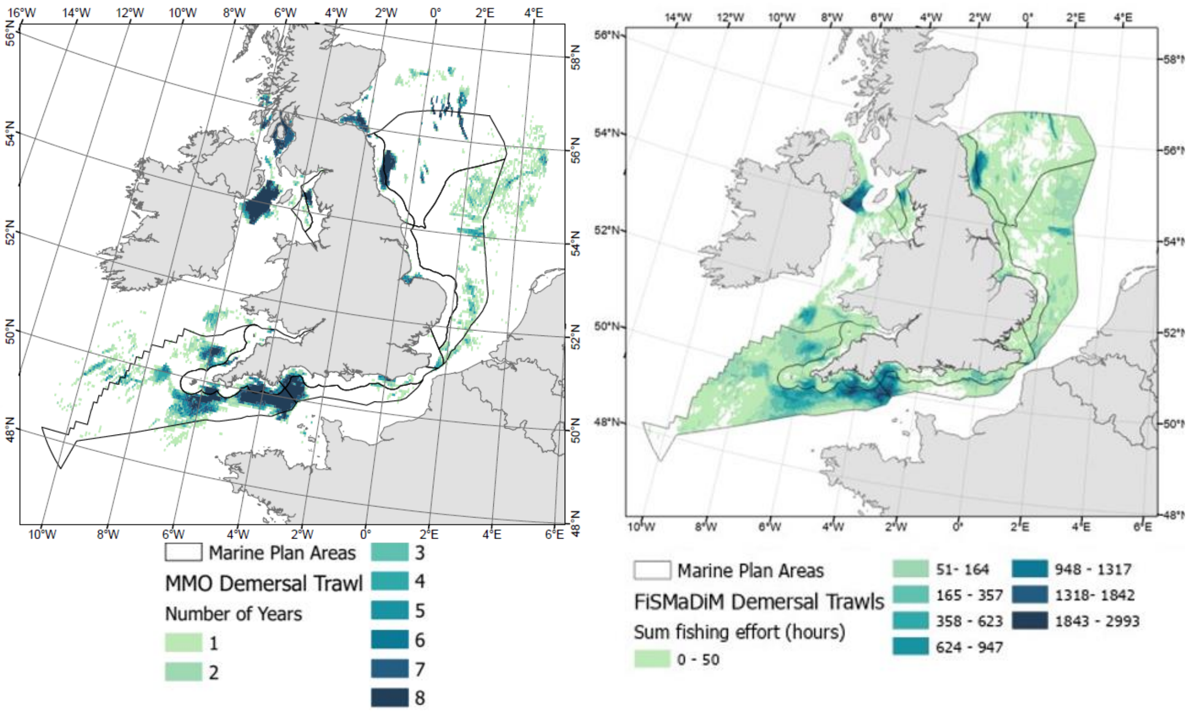


Figure 37. Comparison of MMO important areas for UK 12-metre and over vessels 2016- 2023 for demersal Trawl (left) vs FiSMaDiM sum fishing hours for demersal Trawl (right).

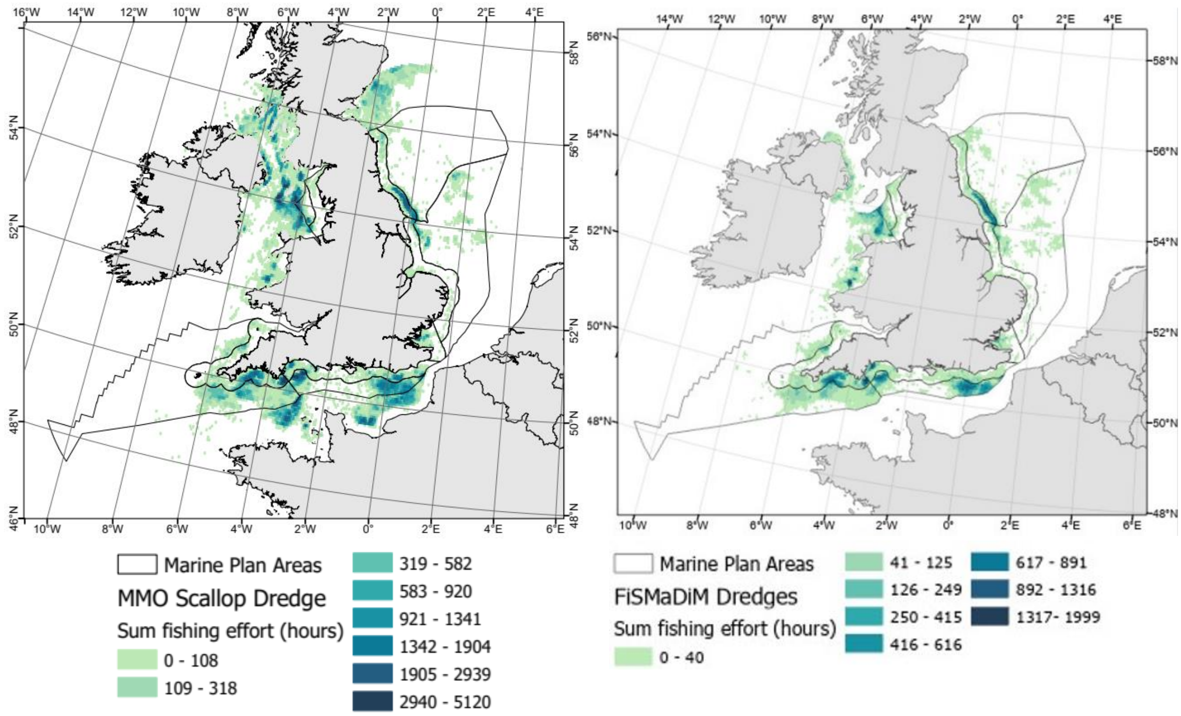


Figure 38. Comparison of MMO important areas for UK 12-metre and over vessels 2016-2023 for scallop dredge (left) vs FiSMaDiM sum fishing hours for Dredges (right).

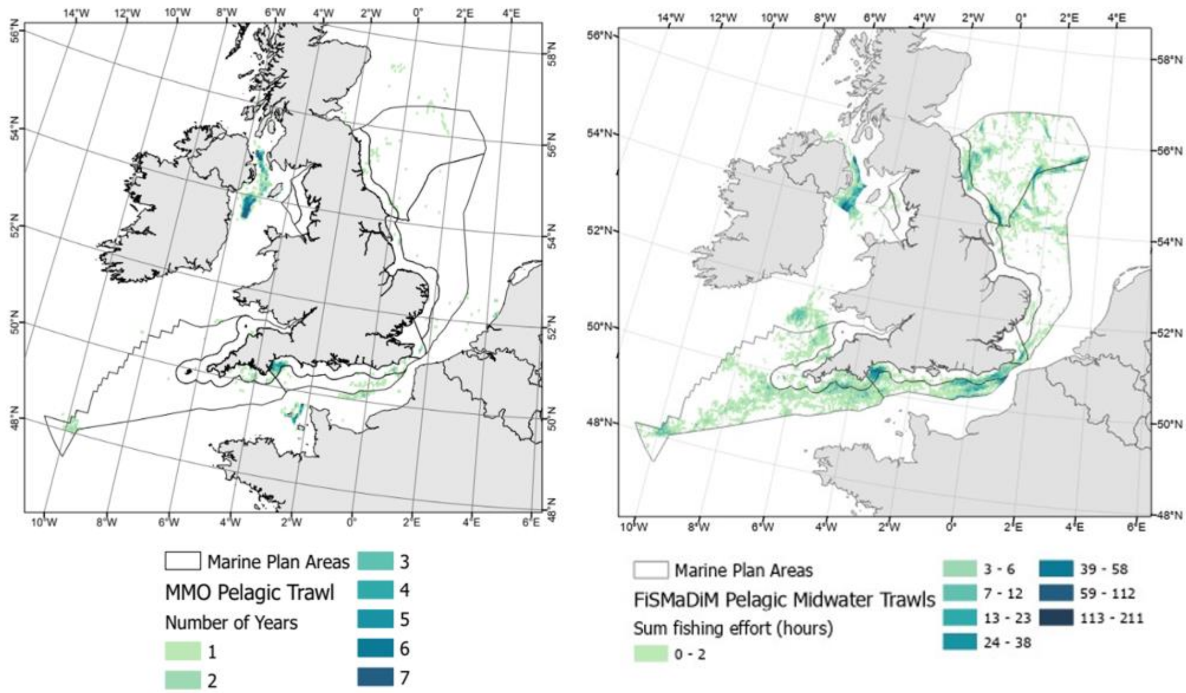


Figure 39. Comparison of MMO important areas for UK 12-metre and over vessels 2016- 2023 for pelagic trawl (left) vs FiSMaDiM sum fishing hours for pelagic trawl (right).

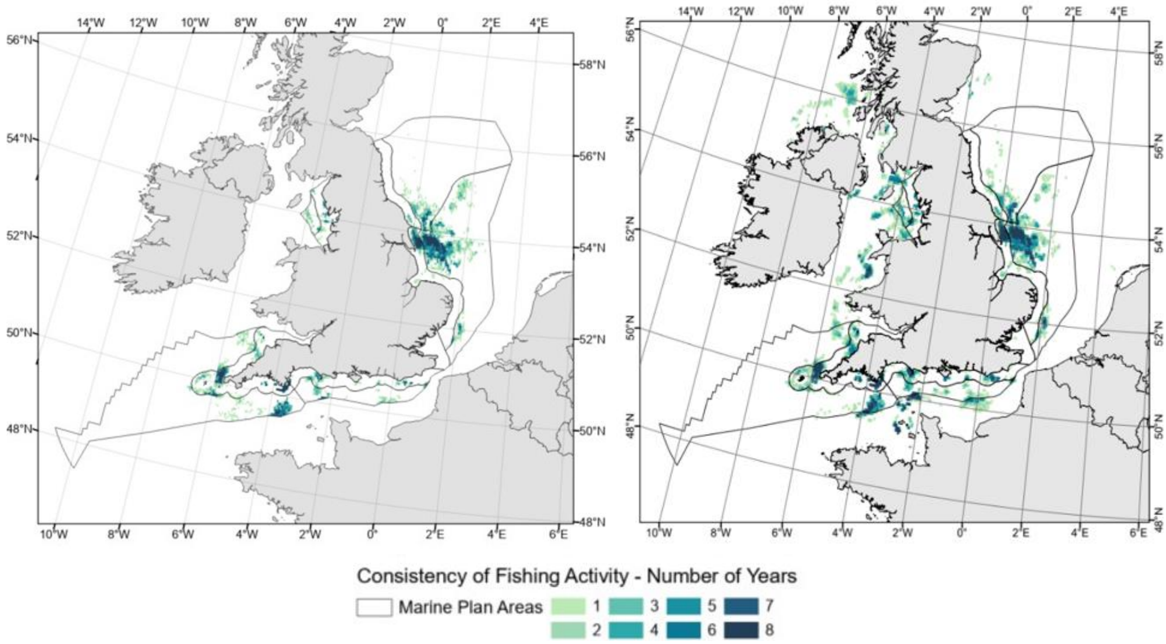


Figure 40. Comparison of areas which are included in both MMO important areas and FiSMaDiM datasets for pots and traps (left), vs MMO Important Areas for pots and traps (right).

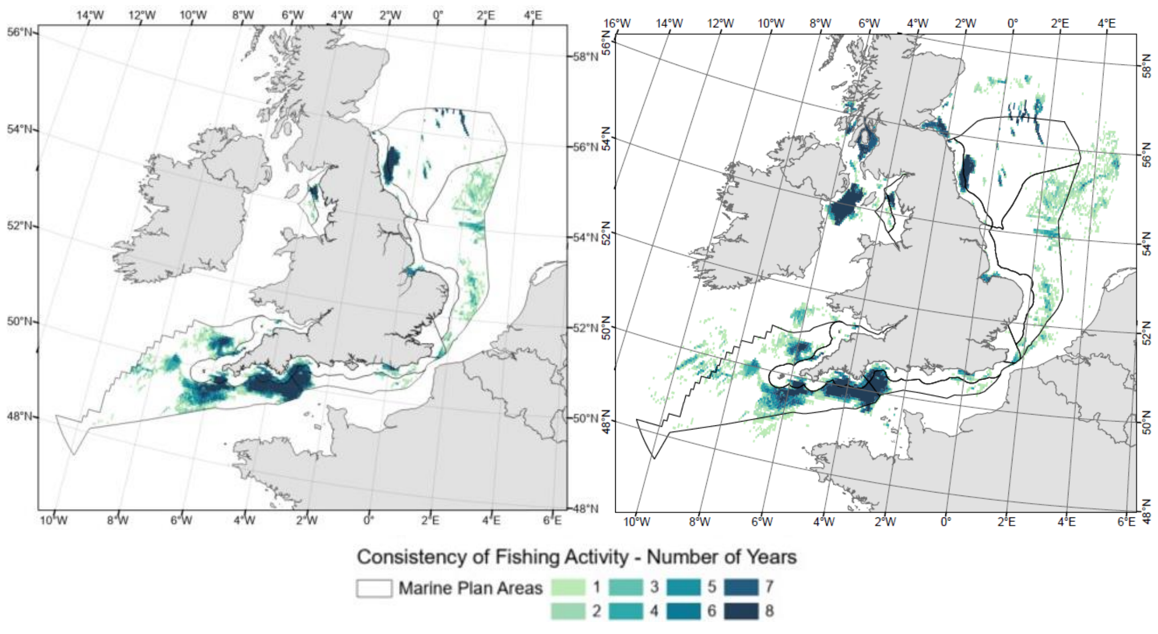


Figure 41. Comparison of areas which are included in both MMO important areas and FiSMaDiM datasets for demersal trawls (left), vs MMO Important Areas for demersal trawls (right).

Table 11. Overlap proportions between MMO important fishing areas and FiSMaDiM areas.

Gears	MMO important fishing areas effort (hours) compared to FiSMaDiM effort (hours, UK vessels only)			MMO important fishing grounds value compared to FiSMaDiM Fisheries Sensitivity Index 1 (UK vessels only)		
	Areas identified by both MMO & FiSMaDiM	Additional areas identified by FiSMaDiM as potential areas of interest for fishing		Areas identified by both MMO & FiSMaDiM	Additional areas identified by FiSMaDiM as potential areas of interest for fishing	
	% of total MMO important fishing areas	Km^2	Proportion additional areas	% of total MMO important fishing areas	Km^2	Proportion additional areas
Pots and Traps	99%	72,611	232%	97%	58,674	195%
Dredges	99%	48,290	281%	98%	47,467	294%
Demersal Trawls	100%	134,152	255%	100%	123,234	276%
Seine Nets	91%	29,125	326%	90%	19,418	263%
Pelagic Midwater Trawls	89%	74,591	1027%	87%	43,484	672%
Gill and Entangling Nets	100%	43,543	195%	98%	34,128	151%
Surrounding Nets	95%	4,348	529%	86%	1,861	363%

The utility of the different datasets for analysis depends on the specific information needs of the user. The MMO important areas dataset emphasises areas of high fishing value and importance, using a simplified metric to highlight zones of concentrated activity. In contrast, and as seen in **Table 11**, the FiSMaDiM project captures a broader spatial picture, including areas of lower activity that may still hold relevance for certain fisheries or future planning, and FiSMaDiM's sensitivity indices incorporate multiple dimensions of economic importance through six distinct indicators, providing a different view on fisheries importance. A similar approach could also be achieved by doing further investigations to the cumulative MMO datasets which are not sliced to produce the "important areas".

Generally, and as there is good alignment and agreement on most importance/high intensity areas, the datasets can be used to complement each other. Using both MMO and FiSMaDiM products together will provide the most certainty over whether an area is 'important', and further spatial analysis on areas which appear in both datasets (such as in **Figures 40 and 41**) may aid policy and decision-making in identifying with confidence areas of especial importance.

This will ensure the full picture of impacts of restrictions or displacement on the UK 12-metre and over fleet are captured, and minimise the risks associated with the caveats for both approaches by understanding activity in a relevant area.

Future potential for development

There is potential to develop this work further through additional exploration of the existing data and through processing new useful information which help to build upon our understanding of fishing activity around the UK. There is also potential to improve accessibility to the data to allow others to benefit from it.

An immediate next step for development should be the validation of the data with the fishing industry to better understand if this largely theoretical data matches real world practices. This should be done in partnership with representative for and from the fishing industry, as well as with members of the industry directly.

Additional refinement of the method for validation of the 80% threshold value needed, as initial trials in this work demonstrated that the current method was flawed. This is especially where spatial extent of the data is limited. The method should be improved by plotting all processed data points rather than splitting aggregating into cumulative deciles, followed by statistical analysis to understand exactly at what value a best-fit line of these points reaches a gradient of 1.

Publication of the data in an accessible web platform, such as an ArcGIS online webmap or the Explore Marine Plans web service would also benefit marine users, as there is only so much that can be gained from examination of static maps and data tables within a written report. In this way data could be shared in a more accessible manner, benefiting marine developers, users and policy-makers to better understand and mitigate against potential impacts to the fishing industry.

Major value would be gained from the port counts layer, as it would allow developers, decision and policy-makers to identify which ports are using which areas of the sea, thereby allowing for a more targeted consultation and engagement process, ensuring that the right stakeholders are made aware of plans and proposals and given a reasonable opportunity to make any representations with regard to them.

To further expand our understanding of fisheries at a local scale, there would be value in working to better map supply chains and land-based employment related to the fishing industry so that a greater understanding of potential indirect impacts can be gained. This could potentially build upon the work produced by the Cornish Fish Producers Organisation – True Value of Seafood Report. Another way to improve our understanding of local impacts would be to again map port usage, however where this report has looked at port of landing there may be value in looking at the ports at which vessels are registered. This may give an indication of areas which may also be economically dependent upon the fishing industry but are not major ports for fish landing, or do not have the necessary infrastructure to support landing fish. Additionally, interesting information may be drawn from further examination of the existing port data, for example calculating commuter distances for different ports.

While both species landings data and gear data has been mapped, with a small amount of visual comparison to relate species with the gears used to target them, further work could be done to better understand the relationship between the species-gear connections. In theory mapping species catch location should reflect the gears they are caught with, so developing an understanding of the proportion of each of your species caught by each of the gear groups may be useful when making gear and species matches. Analysis could be undertaken to determine whether the relationship between each species and gear is one-to-many, many-to-one or one-to-one.

While visual inspection confirms that the spatial patterns of UK 12-metre and over fishing activity remain broadly consistent across different metrics—Effort (kWh), Effort (hours), Value, and Weight—there is scope for a more robust, quantitative analysis to substantiate this observation. A future analytical step could involve a c-square-based comparison of these metrics by calculating the percentage deviation between corresponding values. For example, subtracting one normalised metric raster from another would produce a deviation surface centred on zero, where values closer to ±5% would indicate a strong agreement between metrics, and larger deviations could highlight specific areas of divergence.

This analysis could be summarised statistically, for instance through histograms showing the distribution of deviation values, or by calculating the proportion of c-squares falling within defined deviation thresholds (e.g. ±5%, ±10%). Such an approach would allow us to quantify the extent and spatial distribution of metric similarity and identify areas or patterns where discrepancies are most pronounced. This would provide a more objective foundation for interpreting metric choice implications in national-level fisheries mapping and support evidence-based decision-making, and refine our understanding of the differences in the size of important areas between different metrics (for example, the value important area is 50,000 km^2 larger than the effort important area).

It would be further beneficial to map changes in fishing activity across all metrics, species and gears against changes in quotas and fisheries closures because of byelaws. This would confirm and refine our understanding of the impact of such changes on fishing activity.

The comparison between the MMO and FiSMaDiM datasets presented in this report has been based on a visual assessment of spatial patterns across the gear group classes. While this provides valuable initial insights, a more rigorous quantitative analysis could strengthen the comparison and support more detailed interpretation. One potential approach would be to normalise the two datasets to reflect relative effort within each class. For instance, if the first class in the FiSMaDiM dataset for a specific gear like pots and traps is defined as 1–75 hours, this represents only 0–2.26% of the maximum observed value (3,312 hours), and this variation in scale should be accounted for in any analytical comparison.

By converting both datasets to percentage-based scales and standardising class intervals accordingly by using percentage values, it would then be possible to perform a spatial overlap analysis. This would involve calculating the proportion of spatial agreement between the two datasets for each class for each gear group, providing a more robust measure of alignment or discrepancy between them. Such an approach could also help identify patterns of agreement at different activity levels and inform more targeted interpretation or policy responses. Identifying which areas are common between the two datasets may also be useful in policy and decision-making, as they could potentially represent high confidence areas of especial importance to the fishing industry.

As iVMS data becomes more mature, its integration into GeoFISH will allow for more accurate mapping of the UK under 12-metre fishing fleet, offering a way to fill the data gap that currently exists around the spatial distribution of this fleet segment. Additionally, if fisheries data sharing between the UK and EU is expanded there would be further potential to develop the mapping of the non-UK fleet, potentially allowing for landings linked data which would again increase our understanding of the value of different areas of the sea for the fishing industry.

It may also be interesting to break the raw data down further than annually, allowing for the identification of any seasonal patterns in fisheries which may indicate that certain areas are more important than others at specific times of the year, which could potentially support seasonal licence conditions for developments or highlight potential co-existence opportunities.

Finally, the development of an MMO owned GeoFISH equivalent product would likely improve the frequency at which spatial fisheries data can be released, improve MMO confidence in the data, and remove reliance on Cefas – which has caused considerable challenges throughout the lifespan of the project.

Annex 1: Phase Two Full Methodology

The following is an extract of the Methods section of the Fisheries Mapping Technical Report 2022 which supported the first round of fisheries activity mapping completed in 2022.

Data sources

This project utilises the three best available evidence datasets covering the majority of commercial sea fishing in UK waters.

- UK 12m and over vessels
- UK under 12m vessels
- Non-UK 12m and over vessel

The three datasets represent different fleet segments with different mandatory data submission requirements and historic data sharing arrangements. As such data supporting each fleet segment has different spatiotemporal resolution, ability to link other data and confidence levels. The data sources are described further below

UK 12m and over vessels

The UK 12m and over vessels fishing activity dataset (UK12m+) draws on VMS linked fisheries aggregated data extracted from the Cefas GeoFISH spatial database. GeoFISH is built on top of the system the integrated UK database (IFISH) that contains UK VMS and e-logbook data (data for England sourced from the MMO).

GeoFISH was designed to meet the international reporting requirement set by ICES to map the aggregated distribution of fishing by different gear types across the OSPAR area, and to evaluate the spatial and temporal effects of fishing. GeoFISH combines VMS position with logbook data and automates the calculation of relevant fisheries metrics through spatial apportionment of landings to VMS data. It uses open-source technologies. Related code such as fishing speed or catch to ping allocation rules can be retrieved from the Cefas github repository (https://github.com/CefasRepRes/GeoFISH).

GeoFISH, while robust for intended uses to support UK submission to ICES, is still developing as a system to manage UK fisheries geospatial data more generally. Due to current technical restrictions, it was not possible for the MMO to access GeoFISH directly within this project and therefore this project utilised an existing current geodatabase extracted from GeoFISH by Cefas partners.

The geodatabase included only UK 12m+ VMS linked activity data containing the following fishing activity metrics

- Effort (hrs/days)
- Effort (KwHrs)
- Landings Value (Tonnes)
- Landings Value (£GBP)
- Swept area ratio

Data had the following characteristics

- Temporal extension: 2016-2021
- Temporal resolution: Quarter year
- Geographic extension: ICES waters
- Geographic resolution: 0.05^{o} c-squares
- Fleet segment Gear resolution: Metier Level 4 gear codes

Of the fishing metrics, only the swept area ratio was not used in this project. Further, it was not possible to assess seasonality within the projects' timeframe. The geographic extent of the data was cropped to an area of interest that included English waters as well as waters administered by Welsh and Northern Irish fisheries administrations plus a 100km buffer. Some data that could have been of interest to the project (e.g., vessel size or vessel nationality) were not included in the geodatabase extracted from GeoFISH although these could be available for future analysis with further resourcing.

UK under 12m vessels

Under 12m fishing activity data were generated from bespoke extractions from two separate MMO data holdings for effort and landings. Effort data were extracted from the European Scientific, Technical and Economic Committee for Fisheries (STECF) fleet economic reporting provided by MMO while landings data were extracted from the live MMO database iFish2 and represent slightly different snapshots. Both datasets are based on logbooks and sales notes data provided by fishers or sellers to MMO as part of statutory requirements, but attempts were not made to link the two datasets. While unlinked data is suitable for the analysis undertaken here, future analysis would benefit from establishing a linked dataset.

The dataset and geodatabase contained the following fishing activity metrics:
STECF fleet economic reporting

- Effort (vessel days at sea)
- Effort (kW days effort)

iFish2

- Landings Value (Tonnes)
- Landings Value (£GBP)

Both datasets had the following characteristics:

- Temporal extension: 2016-2021
- Temporal resolution: Annual
- Geographic extension: UK waters
- Geographic resolution: International Council for the Exploration of the Sea (ICES) rectangle
- Fleet segment Gear resolution: MMO Gear codes
- Fleet segment Vessel size: Under10m and 10m to under 12m vessels

Non-UK 12-metre and over vessels

While the transition of the UK to an independent coastal state has enabled the UK to gain access to higher resolution fishing activity data from non-UK vessels, accessing and managing that data is still transitional and MMO lacks retrospective data.

The UK fishing authorities receive VMS data for all fishing vessels 12-metre and over within UK waters. Historically however, linked logbook data was not shared and thus it is not possible to analyse non-UK vessel VMS data with the same confidence and methods that are to be applied to equivalent UK vessels.

Off the shelf VMS based fishing activity products of non-UK data in UK waters only include aggregated datasets at ICES rectangle resolution supplied by the European STECF. There are also products from ICES that record effort (but not landings) from common gear types (but not all gears) at c-square resolution. However, anonymity requirements make it impossible to separate UK and non-UK data.

This project therefore used a non-UK ping density dataset linked to the fleet registry (that contained gear type at vessel registration) that was being formulated to support MPA byelaws work being undertaken in MMO.
The geodatabase contained the following attributes:

- Temporal extension: 2016-2020
- Temporal resolution: Annual
- Geographic extension: UK waters and surrounding waters
- Geographic resolution: Point data aggregated to 0.05^{o} c-squares
- Fleet segment Gear resolution: Metier Level 4 gear codes[4]

The geodatabase contained the following fishing activity metrics:

- Effort (ping density)

[4] ICES standard vocabulary https://vocab.ices.dk/?ref=1498

Ping density is only a proxy for effort. If ping rates were at a consistent 2hr rate, then ping density and time-based effort would be perfectly correlated. However, it is possible to uprate pings under certain contexts such as in proximity to protected areas for more targeted regulatory assurance. It is assumed that uprated pings are a small minority of the dataset and thus do not significantly impact corresponding conclusions. Time pressures and availability of technical expertise precluded converting individual pings to time corrected effort measures within the project timeframe.

There were no landings data available for non-UK fishing activity other than STECF data at ICES rectangle resolution. Given the close correlation between fishing activity metrics observed in iterations of this report, no effort was made to analyse non-UK landings data as such coarse data would not be informative over activity intensity based on ping density.

Employment

Employment metrics were created by scaling time-based fishing effort statistics (hours for the UK 12-metre and over and days for the UK under 12-metre segment) and scaling it by estimates of vessel crew size to give person hours or person days.

Average crew sizes were obtained from the 2021 Employment in the UK Fishing Fleet[5] data. This data provides average crew size from a survey of 788 workers taken in the summer of 2021. Data are reported to fleet segments although there is a poor match between the fleet segments used in the employment data and those that MMO can create with available data at this time.

Geospatial Analysis

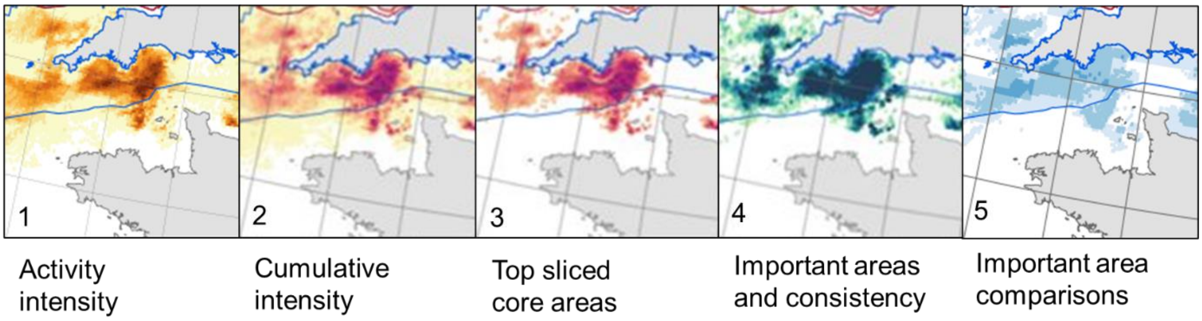
All geospatial analysis used ArcGIS Pro.(ESRI) with map visualisations to the ETRS 1989 co-ordinate systems and Lambert Azimuthal Equal Area Projections. The workflow was as follows;

1) Fishing activity intensity data was mapped for each fleet segment using natural breaks symbology on otherwise unmodified data.
2) Fishing activity intensity was recalculated to cumulative fishing activity intensity by ranking intensity (from highest to lowest) and cumulated before then scaling to the proportion of total cumulative effort. Proportion of total cumulative effort was the basis for mapping cumulative activity intensity as deciles of cumulative activity i.e., top 10%.

[5] https://www.seafish.org/document/?id=7d65694d-7f4f-4bfc-acd0-eb4d6c66a549

3) The top 80% of fishing activity was top sliced following the thresholds approach agreed for each year to generate year by year core fishing areas.
4) Interannual variability and important areas were then derived by calculating the interannual consistency of core areas, i.e., the number of years over which a particular area was identified as core area.
5) The interannual stability of core areas was assessed using the number of occurrences an area was identified as core within the study period. Important areas were defined from merging the overlapping core areas.
6) Combining important areas from different cuts of data e.g., activity metrics and gear types of fleet segments, was then used to assess spatial overlap.

“Figure 1.” Graphic workflow of geospatial analysis.



Natural England Environmental Sensitivity Tool

In exploring some of the sustainability considerations around defining important areas for fishing, MMO collaborated with Natural England to pilot using the Natural England Spatial Sensitivity Tool (NESST) to explore habitat sensitivity to pressures from fishing.
A technical annex has been provided by Natural England to go alongside this report that allows NESST outputs to be understood fully and applied correctly. This document draws from that technical report to illustrate how the important areas and NESST sensitivity analysis intersect.

To summarise, NESST combines spatial information on seabed habitat types from a ranges of modelled and survey sources and links it to sensitivity information for habitats (or habitat proxies) for a range of different pressure types. For fishing gears that contact the seabed, surface abrasion and sub-surface abrasion are the most relevant pressures. The tool outputs sensitivity to pressure maps along with spatial confidence scores for that sensitivity assessment.

MMO provided active demersal fishing activity for input to NESST. Outputs were generated across the ranges of spatial scales at which fishing activity is available and applied in this report (0.05° c-squares to ICES rectangles) to understand how NESST data may be applied to the different fishing activity data in this study.

Supporting materials

This report has generated a number of supporting materials that can be accessed on request. These include;

- Geodatabases and GIS processing models for the data presented herein
- Over 250 maps showing combinations of fleet segments, fishing activity metrics, processing steps from activity intensity maps through core areas to important area overlaps including at different gear resolutions
- Excel spreadsheets recording the spatial footprints associated with the above maps
- Employment data such as average crew size and its translation from Seafish fleet segments to the fleet segments that could be resolved in this project

Annex 2: Data Manual, Caveats, and Limitations

All mapping and data processing has been undertaken using the European Terrestrial Reference System of 1989 (ETRS 1989).

Data layers

Processed data is split into two main types of data, these being ‘cumulative calculations’ and ‘important areas’.

Cumulative calculations

Cumulative calculations are titled with the following format:

*Grouping*_cumulative_*year*

Examples:

Allgear_cumulative_2016
Cod_cumulative_allyears
NE_Demersal_Trawl_cumulative_2018

Table 12. Details regarding what each of the different fields means within the cumulative calculations layers.

Field Title	Field Description	Grouping Presence
csquare	C-square identification codes	All
SUM_value_gbp	Summed value in great British pounds for that c-square	All
SUM_weight_kg	Summed weight in kilograms for that c-square	All
SUM_effort_h	Summed effort in hours for that c-square	Excluded from species
SUM_effort_kWh	Summed effort in kilowatt hours for that -c-square	Excluded from species
Cum_Effort_kWh	Cumulative effort in kilowatt hours – when c-	Excluded from species

Field Title	Field Description	Grouping Presence
	squares are ranked smallest to largest effort in kWh, the sum of effort in kWh of this c-square and all previous (smaller) c-squares	
Cum_tot_value	Cumulative value in great British pounds - when c-squares are ranked smallest to largest value in great British pounds, the sum of value in great British pounds of this c-square and all previous (smaller) c-squares	All
Cum_effort_hours	Cumulative effort in hours - when cquares are ranked smallest to largest effort in hours, the sum of effort in hours of this c-square and all previous (smaller) c-squares	Excluded from species
Cum_tot_weight	Cumulative weight in kilograms- when c-squares are ranked smallest to largest weight in kilograms, the sum of weight in kilograms of this c-square and all previous (smaller) c-squares	All
Prop_of_tot_value	Proportion of the total value, as a percentage, that the cumulative value in great British pounds of the c-square represents	All
Prop_of_effort	Proportion of the total effort in kilowatt hours, as a percentage, that the cumulative effort in kilowatt hours of the c-square represents	Excluded from species
Prop_of_hours	Proportion of the total effort in hours, as a percentage, that the cumulative effort in hours of the c-square represents	Excluded from species

Field Title	**Field Description**	**Grouping Presence**
Prop_tot_weight	Proportion of the total weight in kilograms, as a percentage, that the cumulative weight in kilograms of the c-square represents	All

To visualise the data the proportion fields (Prop_of_tot_value, Prop_of_effort, Prop_of_hours, and Prop_tot_weight) were used using a graduated colour ramp, manually broken into 10 equal classes at each decile (10%, 20%, 30% etc.).

Important Areas

Important area layers have been titled with the following format:

*Grouping_Metric*_csquare_count

Examples:

Demersal_Trawl_effort_csquare_count
NE_Pelagic_Trawl_value_csquare_count
Cod_value_csquare_count

Table 13. Details regarding what each of the different fields means within the important areas layers.

Field Title	*Field Description*	*Grouping Presence*
COUNT_csquare	A count of the number of years over the time series that a c-square was within the top 80% threshold for that metric.	All
Geo_Area	The geodesic area in square kilometres.	All

To visualise the important areas layers the COUNT_csquare field was used using a graduated colour ramp, broken into a number of classes equal to the number of years in the time series (in this case 8 years).

Key caveats and limitations

The current version of GeoFISH used for this delivery (v5p1) uses logic to apportion landings to decreasing levels of granularity where it is unable to match on any one criteria (e.i. if a match is unavailable on 5 criteria, then one criteria is dropped and another attempt is made). While this may lead to inconsistencies (in some cases assigning landings to incorrect vessels) the approach is largely acceptable, and the majority of landings are robustly matched to vessels and represents the currently best available approach.

Other data gaps remain with value data quality. The MMO have applied fixes to the aggregated data received by Cefas, but these fixes should be more appropriately applied to the GeoFISH inputs instead of the outputs received by the MMO. This is a wider known issue with UK landings data as opposed to a GeoFISH specific issue. However, other data products that use same data have processes in place to correct for this value data issue but GeoFISH does not, hence why a fix was applied to the outputs by the MMO. A wider solution will be required by CEFAS to address this as it cannot be assumed that all landings data will be correct at the point of entry to the GeoFISH database. One possible solution would be to switch the input landings data in GeoFISH to those already processed by the MMO Statistics team, as these have relevant fixes already applied.

It is also significant that there are landings missing from GeoFISH due to an issue with Scottish logbook data transfer to main UK system. The MMO have mechanism in place to append this to the annual sea fisheries statistics report but this is not applied to GeoFISH input data. This may affects 2,000-20,000 tonnes per annum (note UK total landings in 2023 was 719,000 tonnes). While some Scottish vessels fish in English waters the majority fish in Scottish and international waters, which is outside of the scope of this commission thereby minimising the impact of this issue on this work specifically.

There are a number other of caveats and limitations which need to be considered when using the data, these are listed below.

GeoFISH

- **Landings data reporting requirement scale compared to GeoFISH** – Landings data is reported at ICES rectangle level (approx. 55km x 65 km at English latitudes) while this work uses landings data at 0.05^{o} c-square level (approximately 5.5km by 5.5km). Very roughly 100 times smaller. Assumptions therefore need to be made which add a level of uncertainty when apportioning landings data across the VMS pings which underpin the GeoFISH dataset. For example, error could be introduced if 100 tonnes of fish were apportioned equally between two VMS positions but in reality all the fish were caught closer to the time of one of those positions.

- **Fishing speed assumptions** - different speed ranges are used to determine when a vessel is fishing depending on gear type i.e. what speed range does dredging activity occur at. There is uncertainty in the speed of vessels between VMS positions and speed ranges by gear require additional analytical and expert scrutiny.

- **Logbook to VMS match criteria** – a logic chain is required to match logbook landings data to VMS positions (for example a match between the logbook entry, the vessel, the fishing trip, the date, and ICES rectangle), however if a logbook entry cannot be matched using the all logic steps then criteria need to be dropped to make the matching criteria less strict before trying again. This process is repeated until the matching criteria becomes too relaxed to be reasonable. As an example only 82% of weight between 2016 and 2022 was matched on the best match level with remaining matched at lower levels of certainty.

- **Weight mismatches** - at a high level, the match between GeoFISH and published annual landings is good (96-100% for 2016-22), however, at more granular level there are larger mismatches present. For example, ICES rectangle 31F1 weight in GeoFISH is only 62% of the weight in the annual reported statistics. In this case the difference can be explained by GeoFISH method reallocating landings to rectangle 32F1 based on VMS positional data. That appears sensible but there are cases where the method is reallocating with limited evidence to justify suggesting a method logic issue. The impact of missing weight is not consistent across ICES rectangles.

- **Value data mismatches –** there are significant issues in the UK ifish2 database that GeoFISH draws data from and no in-built processes to correct for these. The primary issues identified were: landings with zero value – records with 0 value but weight present; landings with extreme high prices – records with >£50 price per kg. Where possible ad hoc corrections have been applied using species average prices to mitigate against these identified issues. Although this has resolved for certain major cases, significant mismatches remain which need to be fixed in the input data/method rather than in output data. <u>As such values reported should be considered indicative only</u>.

- **Effort mismatches –** When the GeoFISH v5 data has been cut to the MSPri study area for direct comparison with the Phase 2 GeoFISH dataset the effort figures in the new GeoFISH dataset overall are consistently lower than previously for each year. For example, in 2021 overall effort hours was ~595,000 but in

GeoFISH v5 it now totals ~533,000 hours. There is currently lack of clarity on how the method is treating unmatched effort data.

At a broad level, the caveats around matching weight and value to location must not be underestimated. The net effect is that the order of confidence runs effort > weight > value. It is currently unknown the degree to which the limitations impact different areas differently and there are still further uncertainties to be realised, for example do the limitations affect different gear types differently?

Irrespective of increasing challenges from effort to weight to value, it is still worth looking at all the metrics/maps together to ascertain the overall picture.

MMO Data Processing

This analysis inherits all the uncertainties associated with fishing activity data on which this study is based including for example, using vessel speed rules to define fishing and non-fishing vessel movements, allocating landings data to VMS records etc.

Definition of the intent, vision or objectives for important areas better defines what is to be considered important, to whom and for what reason. This in turn suggest more appropriate criteria for analysis and metrics for description. This study used generic ideas of importance based on intensity of use for fishing activity. Policy objectives or stakeholder engagement may suggest other rationales. Steps have been taken to better understand importance at the local community scale but there is still room for improvement of understanding for community dependence or resilience or to account for connections to shore side activity such as processing.

It is likely that many local perceptions of importance do not align to those herein which are at national or strategic scales. This will be a particular issue for inshore fleets where data for mapping is generally poor and was out of scope for this work, and vessel ranges are constrained. Any attempts at local analyses should be in conjunction with stakeholder engagement and with the IFCAs who should be resourced to contribute.

As with any analysis, results have several limitations

Two fleet segments were assessed, UK 12-metre and over and non-UK 12-metre and over vessels. UK under12-metre vessels were not described at all. These vessels may be relevant locally when EEZs are narrow e.g., in the southern North Sea, English Channel and northern Irish Sea.

Due to the granularity of the UK under 12-metre fishing data, it was not considered to be worthwhile to update the analysis undertaken in 2022 as this showed that the majority of ICES rectangles around the coast were important and it is not expected that this would have changed.

Access to spatially resolved non-UK data was a significant impediment to analysis. Landings data were only available at ICES rectangle resolution and no improvement could be made within the timeframe of the project. Landings value and weight metrics were therefore not assessed. It is assumed that, like for UK data, non-UK landings data will show high correlation with fishing activity at least at aggregate levels.

Seasonal variation in important areas was not assessed. It is therefore not possible to assess questions “like do important areas persist throughout the year?”.

Annex 3: Supporting Data Tables and Graphs

Table 14. Total area which constitute "important areas" for each gear type, per year class, where a year class is the total number of years each c-square was considered a "core area". For example, 4567km^2 of the Hooks and Lines important area is made up of c-squares which were only a "core area" for a single year throughout the time series, while no c-squares were "core areas" for 5, 6, 7, or 8 years in the time series.

Number of years	Scallop dredge (km^2)	Pots and traps (km^2)	Gillnets & entangling nets (km^2)	Demersal trawls (km^2)	Surrounding nets (km^2)	Seine nets (km^2)	Pelagic trawls (km^2)	Hooks and lines (km^2)
1	10892	18382	16012	31197	739	6636	12073	4567
2	6678	8553	7690	14320	157	2906	2680	587
3	4753	4709	4870	7777	179	2025	1459	142
4	4334	3243	3216	5754	119	1330	347	20
5	3440	2710	1773	4380	60	1135	291	0
6	3384	2530	1615	3749	20	884	203	0
7	2243	2038	983	6056	60	789	92	0
8	1441	3589	278	16831	0	691	0	0
Total Area	37165	45755	36438	90063	1332	16396	17145	5316

Table 15. Percentage of total area which constitute "important areas" for each gear type, per year class, where a year class is the total number of years each c-square was considered a “core area”. For example, 85.9% of the Hooks and Lines important area is made up of c-squares which were only a “core area” for a single year throughout the time series, while no c-squares were “core areas” for 5, 6, 7, or 8 years in the time series.

Number of years	Scallop dredge (%)	Pots and traps (%)	Gillnets & entangling nets (%)	Demersal trawls (%)	Surrounding nets (%)	Seine nets (%)	Pelagic trawls (%)	Hooks and lines (%)
1	29.31	40.17	43.94	34.64	55.44	40.48	70.42	85.90
2	17.97	18.69	21.10	15.90	11.75	17.72	15.63	11.04
3	12.79	10.29	13.36	8.63	13.42	12.35	8.51	2.67
4	11.66	7.09	8.83	6.39	8.94	8.11	2.03	0.38
5	9.26	5.92	4.87	4.86	4.48	6.92	1.70	0.00
6	9.10	5.53	4.43	4.16	1.49	5.39	1.18	0.00
7	6.04	4.46	2.70	6.72	4.48	4.81	0.54	0.00
8	3.88	7.84	0.76	18.69	0.00	4.22	0.00	0.00

Table 16. Total area which constitute "important areas" for each species, per year class, where a year class is the total number of years each c-square was considered a “core area”. For example, 9661km^2 of the Mackerel important area is made up of c-squares which were only a “core area” for a single year throughout the time series, while no c-squares were “core areas” for 7 or 8 years in the time series.

Number of years	Cod (km^2)	Crab (km^2)	Haddock (km^2)	Hake (km^2)	Herring (km^2)	Mackerel (km^2)	Monkfish and Anglerfish (km^2)	Nephrops (km^2)	Scallops (km^2)	Sole (km^2)	Whiting (km^2)
1	41913	12531	8875	18505	4953	9661	23038	2564	12052	15369	15486
2	14626	5811	3785	7400	1030	1667	12365	2087	6664	5753	6405
3	7391	3804	1778	4434	201	477	8403	988	4814	3025	4068
4	4164	2547	1480	2523	54	117	6170	922	3729	2491	3030
5	2373	1605	839	1414	36	59	3968	905	2948	2210	2290
6	1964	1424	948	1158	18	19	3715	890	3125	1453	2497
7	2429	1803	649	524	0	0	4150	1141	2034	1510	2270
8	1645	2168	506	285	0	0	9475	4955	1410	5289	1360
Total	76508	31697	18862	36247	6295	12002	71286	14455	36780	37105	37409

Table 17. Percentage of total area which constitute "important areas" for each species, per year class, where a year class is the total number of years each c-square was considered a "core area". For example, 80.49% of the Mackerel important area is made up of c-squares which were only a "core area" for a single year throughout the time series, while no c-squares were "core areas" for 7 or 8 years in the time series.

Number of years	Cod (%)	Crab (%)	Haddock (%)	Hake (%)	Herring (%)	Mackerel (%)	Monkfish & Anglerfish (%)	Nephrops (%)	Scallops (%)	Sole (%)	Whiting (%)
1	54.78	39.54	47.05	51.05	78.69	80.49	32.32	17.74	32.77	41.42	41.40
2	19.12	18.33	20.07	20.42	16.37	13.89	17.35	14.44	18.12	15.51	17.12
3	9.66	12.00	9.43	12.23	3.21	3.98	11.79	6.84	13.09	8.15	10.87
4	5.44	8.04	7.85	6.96	0.87	0.98	8.66	6.38	10.14	6.72	8.10
5	3.10	5.07	4.45	3.90	0.58	0.49	5.57	6.27	8.02	5.96	6.12
6	2.57	4.49	5.03	3.20	0.29	0.17	5.21	6.16	8.50	3.92	6.68
7	3.17	5.69	3.44	1.45	0.00	0.00	5.82	7.90	5.53	4.07	6.07
8	2.15	6.84	2.69	0.79	0.00	0.00	13.29	34.28	3.84	14.26	3.64

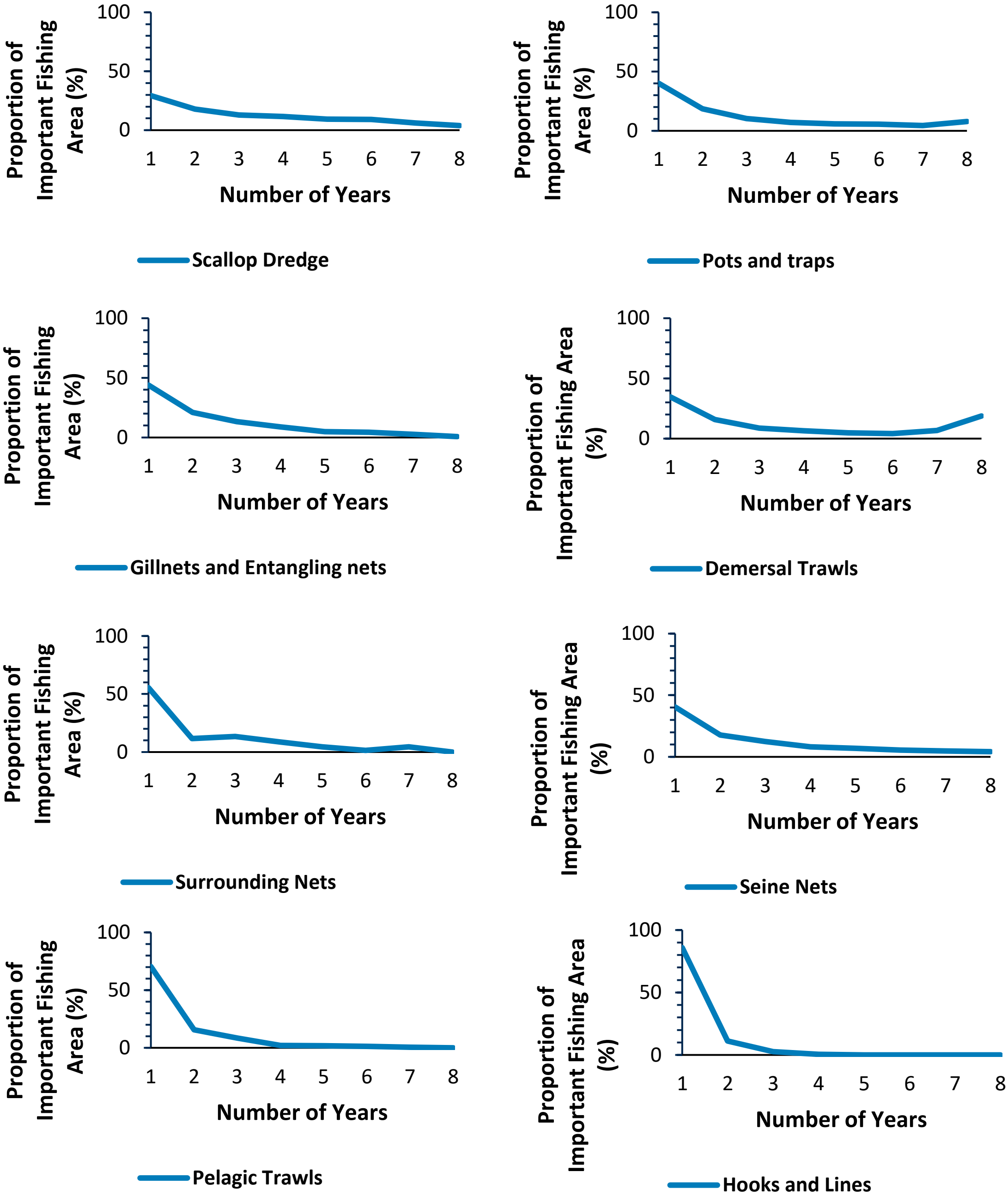


Figure 42. Percentage of total area which constitute "important areas" for each gear type, per year class, where a year class is the total number of years each c-square was considered a "core area". For example, 85.9% of the Hooks and Lines important area is made up of c-squares which were only a "core area" for a single year throughout the time series, while no c-squares were "core areas" for 5, 6, 7, or 8 years in the time series.

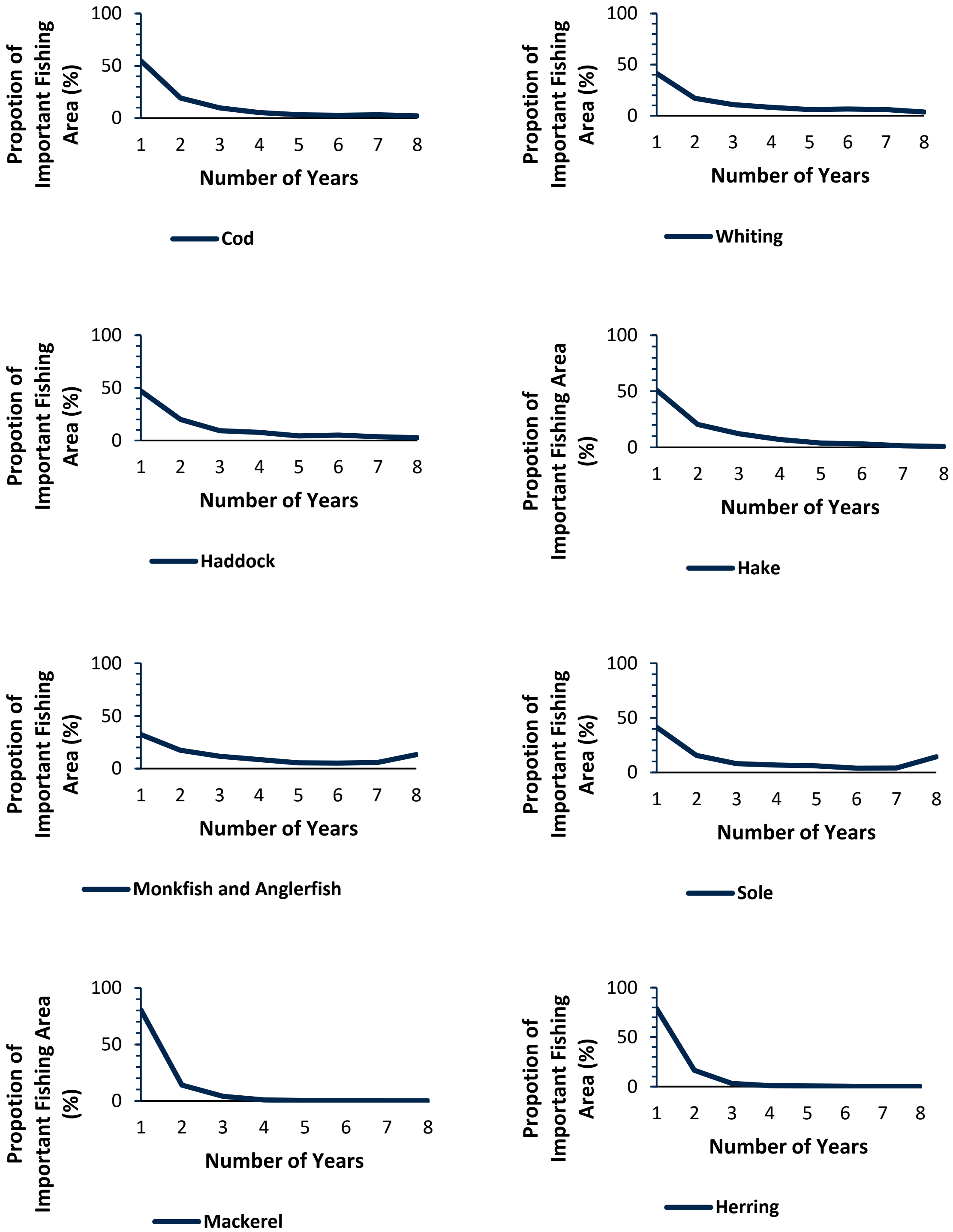


Figure 43. Percentage of the proportion of important fishing area each year between 2016-2023 for selected species landed from the UK 12-metre and over fishing fleet [continued below].

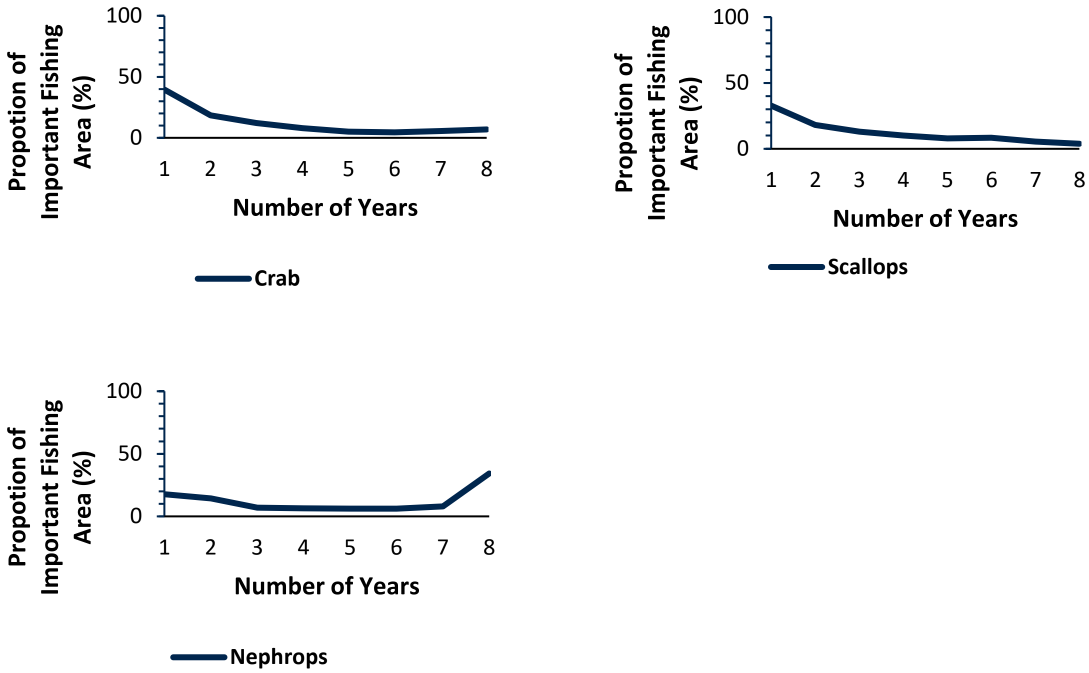


Figure 43. [continued] Percentage of the proportion of important fishing area each year between 2016-2023 for selected species landed from the UK 12-metre and over fishing fleet