Offshore Wind Evidence + Change Programme

Mapping the sensitivity of fishing activities in the UK EEZ

FiSMaDiM Project

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Content

List of Figures

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1. Introduction

The British Energy Security strategy aims to produce 50GW of energy by 2030 with the help of offshore windfarms (OWF). At the same time, the UK government has committed to protect 30% of the sea in the UK for nature's recovery by 2030 (30by30) and the UK Fisheries Act 2020 objective is, among others, to achieve a profitable and sustainable fishing industry which brings social and economic benefits to the UK. Due to all these ambitious commitments of the UK government, the fishing industry pointed out that fishing activity may suffer from spatial squeeze if spatial planning does not consider areas of sensitivity for the fishing industry (ABPmer, 2022; NFFO, 2022). Hence, evidence is needed to understand which fishing grounds are crucial for the fishing industry and therefore should be avoided by, for example, offshore wind development. Avoiding these areas would not only imply lower social and economic impact for coastal communities but also less opposition in the consenting process for OWFs.

To generate some of the evidence, the Crown Estate (TCE) funded the project: Fisheries Sensitivity Mapping and Displacement. Originally an initiative of the Scottish Fishermen's Federation (SFF) and Scottish Government, Cefas together with partners the Scottish Government and the University of St Andrews have taken this project on. We are developing methods to provide evidence on the spatial resolution needed to inform stakeholders in industry and government on the sensitivity of the marine area for the fishing industry.

The project has two core work packages: WP2 to review evidence on the spatial distribution of fishing effort (Mendo et al., 2023) and improve methods to assess fishing effort on high spatial resolution (on-going); and WP3 which is generating sensitivity maps and assess the impact of displacement for the fishing industry. This report focusses on the sensitivity maps and will describe the economic concepts used to capture the importance of the fishing grounds to the fishing industry. These maps can be used at the planning stage to avoid assigning areas important for the fishing industry to other marine activities (e.g., offshore windfarms) and therefore avoiding conflict in the consultation phase.

2. Sensitivity indicators

2.1. Definition of sensitivity

Sensitivity of an area can mean different things to different people in different contexts. For example, the Scottish Government published a mapping tool of sensitivity for seabirds in Scotland (Searle et al., 2019). In this work, sensitivity was implemented by assessing the risk of species-level vulnerability to OWF collision impacts, species-level vulnerability of OWF displacement impacts and sensitivity of the species to change. A review of fisheries displacement and sensitivity of the fisheries to displacement was linked to the availability of alternative fishing ground, knowledge of alternative grounds, individual operating practices, strategies and preferences of fishers including their perception of risk and experience levels, distance from home port to alternative fishing grounds, type and level of fishing activity already present in the alternative fishing ground, and fishing rights and quota availability (Marine Scotland, 2022).

This workstream was set out to capture the economic dimensions of sensitivity of an area to the fishing industry. To be certain that the correct aspects are integrated and that no important aspects are missing from the indicator, we asked the Project Advisory Group (PAG) for their input. The PAG consists of fishing industry representatives (e.g., SFF, SWFPA, NFFO, EEFPO), offshore wind industry representatives (e.g., EDF, Orsted, Ocean Winds, RWE, SSE/OWIC) as well as government agencies (e.g., Defra, JNCC, NE, TCE). Hence, instead of being based on existing literature, sensitivity is here defined based on the opinions of the experts involved in the PAG. The advantage of this approach is that the indicators measuring sensitivity of a fishing ground should reflect local knowledge and aspects relevant to the fishing industry

and the resulting indicators should also be of use for the offshore windfarm industry and TCE, who are all members of PAG.

In a first step, the PAG members were asked at an online meeting on 19th January 2023 to highlight keywords they believe should be captured by the indicators and they think should be reflected in the sensitivity maps. It is acknowledged that the PAG is project specific, and the aspects mentioned by the PAG members may not represent all opinions on what constitutes sensitivity of a fishing ground. However, the aim of this workstream is to capture the main dimensions of sensitivity measuring the importance of the area to the fishing industry. Having representatives from government and industry engaged in the process, we aim to enable consensus and acceptance between the stakeholders on what constitutes a sensitive area for fishing industry.

A short survey using the online survey tool Mentimeter (https://www.mentimeter.com/) was conducted in the meeting with PAG members, asking them 1) whether they are aware of any good examples of impactful measures of sensitivity; 2) to provide 3 words on how they would define sensitivity in this context; 3) impactful indicators for sensitivity they know off; and 4) which dimensions (ecological, economic or social) should be captured most.

With regards to examples of impactful measures of sensitivity, concepts of environmental impact assessment were mentioned in which sensitivity is a combination of vulnerability and recoverability. The PAG members own words on what sensitivity means to them were combined with help of a word cloud (Figure 1). Terms which were mentioned most often evolved around dependence (economic & spatial), vulnerability, diversification, and risk.

Similarly, a word cloud was generated based on the answers given with regards to indicators the PAG members are already aware of. The corresponding word cloud can be found in Figure 2. While this word cloud is dominated by terms such as capacity or income, it also mentioned loss of opportunity, foregone income and economic dependency.

The PAG member agreed that the economic value of an area as indicated by landings value or foregone income, should not be the only dimension considered in the project, but other aspects such as social or cultural impacts should be considered as well.

After the meeting on the 19th January 2023 with the PAG members, several short meetings with fisheries representatives (SFF, SWFPA, NFFO, EEFPO) were carried out to ensure that we correctly captured the aspects of fisheries sensitivity important to the fishing industry. This was to ensure that technical issues or time conflicts did not prevent us from including their opinions into the project adequately.

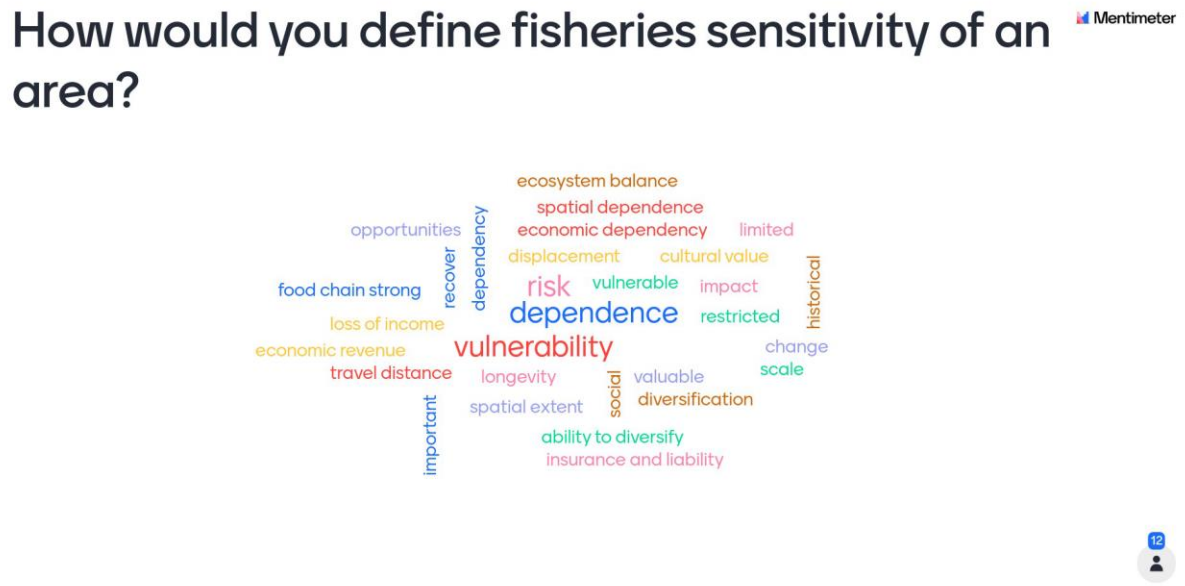

Figure 1: Word cloud with terms suggested by PAG members of how to define sensitivity in the context of the project (PAG meeting 19th January 2023)

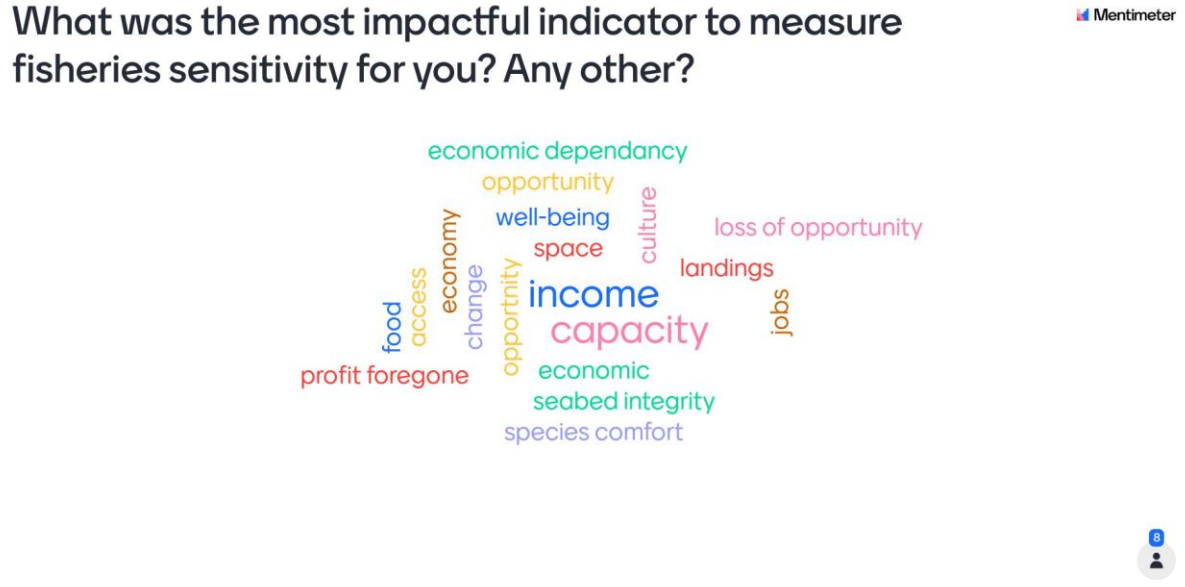

Figure 2: Word cloud with indicators to measure sensitivity as suggested by PAG members in the context of the project (PAG meeting 19th January 2023)

2.2. First draft of indicators

Based on the result from the survey among the PAG member, the following four indicators were compiled in two different versions seeking to capture the aspects mentioned by the PAG members.

Indicator 1 (Business Impact): Measures the number of vessels generating a significant proportion of their revenues in the grid cell. Significant was here defined as larger than the 75th quantile in landing values distribution of the respective year and gear group. **Version a)** provides the absolute number of vessels; **b)**

the percentage of vessels out of all vessels using this gear in that year in the grid cell. *Caveats*: Does not capture seasonality or nomadic behaviour; each vessel is treated as an individual business; number of vessels in the gear category will change over the years and hamper comparability over time.

Indicator 2 (Business concentration): Hirschman-Herfindahl index (HHI) measures the concentration of vessels weighted by the values generated by each individual vessel in a grid cell; **Version a)** HHI (ranges from 0 to 1; the higher the indicator, the higher the concentration of fewer vessels); **version b)** HHI weighted by landing values (high number indicates low number of vessels generating high landing values). *Caveats*: Does not capture regional linkages.

Indicator 3 (Replaceability): Sum of landing values by species in the grid cell weighted by number of grid cells in which each species can be caught in the UK EEZ. *Caveats*: Does not capture relative importance of individual species.

Indicator 4 (Substitutability): Hirschman-Herfindahl index (HHI) measures the concentration of species caught in a grid cell; **version a)** HHI (ranges from 0 to 1; the higher the indicator, the lower the number of species); **version b)** HHI weighted by landing values (high number indicates low number of high value species). *Caveats*: are there thresholds to be considered?; comparability between gear groups?

Indicator 1 and Indicator 2 seek to capture the economic dependence of the fishing industry on the fishing ground. While indicator one is reflecting the number of vessels which are likely dependent on the remaining fishing in the fishing grounds and the value they generate in the area, indicator 2 is capturing whether a lot of vessels generate the overall values in the fishing grounds or whether there are only a few vessels dominating the fishing activity in the area. One could argue that if only a small number of vessels' activity is concentrated in the area, if they cannot successfully be displaced, social impacts of the displacement will impact also only a small number of coastal communities. Depending on the level of activity, this may translate into the level of social impact to be considered when displacing the fishing activity.

Indicator 3 seeks to capture the availability of alternative fishing grounds. Indicator 3 increases with either number of species harvested in the area, landing value generated in the area or number of alternative areas the species was harvest previously. In contrast, indicator 4 captures the concentration of species harvested in the fishing ground. Hence, if the harvest in the area is dominated by one or a small number of species, it might be more difficult for fishers to replace the catch by harvesting the same or alternative species in an alternative area.

All four indicators have one version which incorporates the value of fishing activity in the area to measure the potential income loss to the fishing industry.

A summary of the proposed indicators can be found in

Table 1.

Table 1: First draft of indicators to measure sensitivity of an area for fishing activities as proposed to PAG members on the 8th September 2023.

Indicator 1 (Business impact)	Indicator 2 (Business concentration)	Indicator 3 (Replaceability)	Indicator 4 (Substitutability)
Number of vessels with significant proportion of annual revenues in the grid cell	Concentration of vessels (HHI)	Sum of landing values by species in the area weighted by number of areas each species can be caught (with thresholds)	Concentration of catch composition (HHI)
Proportion of vessels with significant proportion of annual revenues in the grid cell to all vessels using the gear	Landings value weighted by vessel concentration (HHI)	Sum of landing values by species in the area weighted by number of areas each species can be caught (without thresholds)	Landings value weighted by catch composition concentration (HHI)

2.3. Second draft of indicators

The first draft of indicators as found in Table 1 were discussed in the hybrid PAG meeting in Edinburgh on the 8th September 2023. PAG members proposed the following changes in the meeting to the indicators:

1) Proposed changes to Indicator 1 (Business Impact):
   a) Account for revenue per unit effort instead of just revenue.
   b) Provide long-term (multiple years) average instead of annual numbers.
   c) Identify years of specific importance.
   d) Split by season (i.e. provide monthly/seasonal maps).
   e) Change reference points of version b to number of vessels within the individual grid for a given year instead of all vessels harvesting the UK EEZ in the year with the same gear.

2) Proposed changes to indicator 2 (Business concentration):
   a) Link to landing ports to address linkage to processing industry, coastal communities, etc.
   b) Split by vessel sizes.
   c) Link to habitat maps.

3) Proposed changes to indicator 3 (Replaceability):
   a) Separate quota/non-quota species.
   b) Include fraction of individual species catch compared to catch of the respective species in other areas.

4) Proposed changes to indicator 4 (Substitutability):
5) None at this stage.

6) General conclusion:
   a) Indicators 1 & 2 need some fine-tuning but are seen as potentially useful for industry partners, indicators 3 & 4 need more development.

b) While several gear specific indicators are useful for the industry partners (OWF and fisheries), for planning purpose, TCE would prefer one indicator (i.e. explore factor and cluster analysis to combine the different aspects of the indicators to generate one layer indicating hot/cold spots of fishing sensitivity).
c) More thoughts to be given on how to include future changes in management and species distribution into the indicator(s).
d) Indicators need to ensure comparability between gears and over years.

PAG members were also offered to also provide feedback by email after the meeting, but no further comments or requests for changes were provided to the project team.

Based on the feedback of the PAG meeting on 8th September 2023, a second draft of indicators were generated, and the following changes were made to the existing indicators and responses provided to the PAG.

Changes to indicator 1 (Business Impact):

- Indicator 1a – no changes
- Due to lack of reliable effort data, revenue per unit effort maps currently paused [see comment 1a]
- Long-term average included in new indicator 5 [see comment 1b] (defined below)
- Specific years of importance [see comment 1c above] can be identified at a later stage
- Account for seasonality of fishery in new indicator 6 [see comment 1d] (defined below)
- Indicator 1b - reference number of vessels reduced to number of vessels in the grid cell [see comment 1e]

Changes to indicator 2 (Business concentration):

- Link to landing ports will be considered in the development of the webtool [see comment 2a]
- Indicator 2a and 2b were split into vessel size categories following reporting standards: <10; 10-12; 12-15;>=15 [see comment 2b]
- Habitat maps to be included at a later stage [see comment 2c]

Changes to indicator 3 (Replaceability):

- Indicator 3a taken out and replaced by old indicator 3b.
- Indicator 3a separates now between quota/non-quota species and skate landings [see comment 3a].
- Indicator 3b captures now the average fraction of quota/non-quota species of total annual landings value by grid cell [see comment 3b]

No changes to Indicator 4 (Substitutability)

In the meeting, the PAG members stressed that the current indicators are not accounting for temporal variability in fishing, nor for inter-annual changes (nomadic behaviour) or intra-annual changes (seasonal behaviour). To address this concerns, two additional indicators were proposed.

- Indicator 5 (nomadic behaviour): a) maximum and b) standard deviation from 10-years average landings value in the grid cell to address comment 1.2.

- Indicator 6 (seasonal behaviour): a) maximum and b) standard deviation from quarterly average landings value to address comment 1.4.

A summary of the second draft of indicators presented to the PAG members on 13th December 2023 can be found in Table 2.

2.4. Final draft of indicators

The second draft of indicators were presented to the PAG in an online meeting one the 13th December 2023. The following feedback was provided to the individual indicators in the meeting:

1) Indicator 1 (Business Impact):
    a) useful and to be included in current form.

2) Indicator 2 (Business concentration):
    a) include metier were possible instead of just vessel length.

3) Indicator 3 (Replaceability):
    a) Rethink name of the indicator and what it should capture.
    b) Focus should be more on irreplaceability instead of replaceability; suggestions for name included site/location specificity/fidelity.
    c) Contact NE on how irreplaceability of a habitat is measured.

4) Indicator 4 (Substitutability):
    a) To be included.
    b) Estimate the catch composition on vessel level instead of grid level.

5) Indicator 5 (Nomadic behaviour):
    a) Inverse the indicator to consistently fished ground to be considered as constraints for OWF development.
    b) Small spatial changes of fishing activity at this fine-scale spatial resolution may bias the results and should be addressed.
    c) Consider renaming to inter-annual variability indicator.

6) Indicator 6 (Seasonal behaviour):
    a) Small spatial changes of fishing activity at this fine-scale spatial resolution may bias the results and should be addressed.

It was agreed that individual indicators will be combined by statistical analysis as soon as the individual indicators are agreed on.

PAG members were also offered to also provide feedback by email after the meeting.

The following comments were received:

3) Indicator 3 (Replaceability):
    d) Three dimensions captured in one indicator as such a high value might be driven by high landings value but not necessarily the number of areas the species could be harvested in or the number of species to be found in area. Maybe combining indicator 3 with indicator 4 might solve the issue.

4) Indicator 4 (Substitutability):
    c) Instead of using concentration of species catch in the grid, use concentration of gear type in the area to be able to link economic impact.

5) Indicator 5 (Nomadic behaviour):
    d) Using the maximum difference might be misleading and therefore should not be used.

Indicator 5 and indicator 6 should rather not be integrated with indicator 1-4 as they are capturing temporal variation and not economic importance.

The comments received where implemented as follows:

Indicator 2 (Business concentration): Data on metiers is patchy and current definition of metiers is currently reassessed, therefore we would like to pause the adaptation of including metiers and keep vessel lengths to distinguish between vessel groups (see comment 2a).

Indicator 3 (Site specificity):
- Rename to "Site specificity" (see comment 3a, 3b).
- Neither JNCC nor NE provided an example on how irreplaceability of a habitat is measured, and therefore could not be further incorporated (see comment 3c).
- The indicator's version a is changed to the number of species which are harvested irrespective of the gear used in only a small amount of grid cells. This accounts for those species which are not widely catchable and therefore alternative fishing grounds might be limited. Changing this indicator reduced the dimension of the indicator to two by excluding the landing values which is captured in the version b. This should ease the interpretation of the indicator (see comment 3d).

Indicator 4 (Substitutability):
- Version a is now capturing the average catch concentration (HHI) of the vessels harvesting the grid, capturing the portfolio/diversification of the individual vessel, a proxy for the adaptive capacity of the vessel owner (see comment 4b).
- Version b is seeking to generalize the fishing activity and captures the concentration of the different gear groups in the grid (see comment 4c).

Indicator 5 (Inter-annual variability):
- Version a is changed to number of years the grid was harvested by the respective gear group within the last decade (see comment 5a).
- The bias due to relative insignificant spatial changes of fishing activity will be addressed in the climate change assessment to follow this work stream 5b).
- Renamed to inter-annual variability indicator (see comment 5c).

Indicator 6 (Seasonal behaviour):
- The bias due to relative insignificant spatial changes of fishing activity will be addressed in the climate change assessment to follow this work stream. (see comment 6a).
- To capture the intra-annual variability better and allow generalization the indicator was changed to a) number of months the area was harvested in in average in the last decade and b) Standard deviation of long-term average monthly landings values. (see comment 5d).

The final version of the indicators can be found in Table 3. To visualize how these indicators compare to the standardly used annual landing values generated in an area, some example maps based on data from Vessel Monitoring Systems (VMS) are provided in the Appendix, section 6.1.

Table 2: Second draft of indicators to captures changes as suggested by PAG members on the 8th September 2023.

Indicator 1 (Business impact)	Indicator 2 (Business concentration)	Indicator 3 (Replaceability)	Indicator 4 (Substitutability)	Indicator 5 (Nomadic behaviour)	Indicator 6 (Seasonal behaviour)
a) Number of vessels with significant proportion of annual revenues in the grid cell	a) Concentration of vessels (HHI) **split by vessel sizes <10; 10-12;12-15;>=15m**	a) Sum of landing values by species weighted by number of grid cells each species can be caught in **split in TAC, Skate, non-TAC species (not stock)**	a) Concentration of catch composition (HHI)	a) Maximum difference of annual landing values to long-term average landings value	a) Maximum difference of quarterly landing values to long-term quarterly landings value
b) Proportion of vessels with significant proportion of annual revenues in the grid cell **of all vessels active in the grid cell**	b) Landings value weighted by vessel concentration (HHI) **split by vessel sizes <10; 10-12;12-15;>=15m**	b) Fraction of landing values obtained by TAC species in the grid cell	b) Landings value weighted by catch composition concentration (HHI)	b) Standard deviation of annual landings values	b) Standard deviation of long-term average quarterly landings values

Colour symbols: Green – no changes to the indicator; Orange – small changes to the indicator (highlighted in bold); Blue – new indicator; Red – indicator potentially to exclude.

Table 3: Final draft of indicators to address concerns raised by PAG members.

Indicator 1 (Business impact)	Indicator 2 (Business concentration)	Indicator 3 (Site specificity)	Indicator 4 (Substitutability)	Indicator 5 (Inter-annual variability)	Indicator 6 (Seasonal behaviour)
a) Number of vessels with significant proportion of annual revenues	a) Concentration of vessels (HHI) split by vessel sizes <10; 10-12;12-15;>=15m	a) Value of species which are only harvested in a small number of grid cells.	a) Average catch concentration (HHI) of the vessels harvesting the grid cell.	a) Number of years grid cell was harvested in the last decade	a) Number of months the grid cell was harvested in average in the last decade
b) Proportion of vessels with significant proportion of annual revenues in the grid cell of all vessels active	b) Landings value weighted by vessel concentration (HHI) split by vessel sizes <10; 10-12;12-15;>=15m	b) Fraction of landing values obtained by TAC species	b) Concentration (HHI) of gear groups harvesting the grid cell.	b) Standard deviation of annual landings values	b) Standard deviation of long-term average monthly landings values

Colour symbols: Green –indicators accepted by PAG; Orange –significant changes to the indicator.

3. Application – An example

To inform spatial planning, the indicators would need to be implemented using data on fishing activity. To illustrate on how this could be done, data from the Vessel Monitoring System (VMS) was used from the years 2012-2020 in the following example. It should be noted that VMS data is only available for vessels above 12m vessel length, hence the following application of the indicators only incorporates larger vessels with UK flags that are reporting fishing activity to MMO within the UK Exclusive Economic Zone (EEZ).

Generating spatial layers for each indicator (12) for each of the gear group (8) and vessel length categories (4) for each year (9) would result in more than a thousand layers in a geographic database or spatial datasets. As this is not well suited to inform marine spatial planning, the sensitivity indicators were collated into a combined index. In order to do so, in a first step, the sensitivity indicators are categorized whether (1) they are capturing the economic sensitivity of an area for the fishing industry or rather (2) providing context for policy makers on the characteristics of fishing *in situ*. Indicator 5 & 6, for example, were classified as context, providing information such as the inter-annual variability of the fishing activity or the seasonal variability. Similarly, the concentration of gear groups employed (Indicator 4b) was considered as context-providing information. In contrast, indicators capturing the impact (Indicator 1 a, b) and concentration of the fishing businesses in the area (Indicator 2 a, b), the specificity of the site for the fishing industry (Indicator 3 a, b) or substitutability of the catch in the area (Indicator 4a) were classified as sensitivity indicators in the stricter sense. An overview of the classification of the indicators can be found in Table 5.

To ensure comparability, firstly the individual indicators identified as sensitivity indicators in a narrow sense were z-standardized (mean 0, standard-deviation 1) for each gear group and year. Secondly, each indicator was only used in one version, hence the indicator 2 (a, b) was only used for vessels above 12-m vessel length as VMS does not include vessels below 12m vessel length. Although fisheries representatives in the PAG pointed out that vessel length categories should be accounted for, in this application no further vessel lengths categories were implemented. For indicator 3 (a, b) and 4a, only the version related to species under current quota management (referred to as TAC species) were included to reflect the fact that fisheries representatives in the PAG emphasized the importance of quota species.

The correlation between the indicators was estimated to understand whether they are all depicting difference in characteristics as intended or whether one of them is redundant. The correlation of the indicators can be seen in Table 4. Although some indicators correlate highly with each other's, none of them is to such a high level to be deemed redundant.

Table 4: Correlation of indicators to be combined into a Sensitivity Index

	Indicator 1a	Indicator 1b	Indicator 2a	Indicator 2b	Indicator 3a	Indicator 3b	Indicator 4a
Indicator 1a	1						
Indicator 1b	0.1269	1					
Indicator 2a	-0.4546	0.6650	1				
Indicator 2b	-0.0862	0.2216	0.2837	1			
Indicator 3a	0.0270	0.0266	0.0222	0.5182	1		
Indicator 3b	-0.0041	-0.0745	-0.0491	0.0415	-0.0242	1	
Indicator 4a	0.7208	-0.1174	-0.4740	-0.0997	-0.0122	0.3047	1

The data was further tested using only the gear group “bottom trawl” to look at whether the indicators could be combined with the help of factor analysis. Although data meet suitability criteria for factor analysis, it was estimated that the optimal amount of factor (i.e. the combination of indicators based on their distribution characteristics) is five – hence would only reduce the number of indicators by two. As this would not lead to a more practicable solution to include the indicators into policy, this approach was not further pursued. Instead, a ranking approach was applied based on the distribution of the values for each individual indicator estimated by gear group and year and two versions generated.

In a first version, values of each grid cells for each indicator for each gear group and year was reclassified into categorical numbers based on the percentile they belong to within the distribution. As such values in the first quantile were reclassified as 1, values within the second quantile 2, and so on. This resulted in comparable layers for each gear group and year with each indicator given the same weight. As a last step, the categorical numbers from 1-5 were summed up for each gear group and grid cell (ranging from 0-35) and a 3-years (2018-2020), 5-years (2016-2020) and 9- years (2012-2020) average for each of the indicators prepared outputs. Resulting maps can be found in Appendix 6.2 (Sensitivity index 1).

In a second version, a similar approach for reclassifying the values of the grid cells into categorical numbers were used, however, before generating the sum of the number for each grid cell, each year and gear group, a weight was applied multiplying the categorical number of the grid cell with the fraction of years the grid cell scored in the respective indicator. Hence, the overall score was weighted based on the number of years the grid cell was classified as sensitive for the fishing industry. If the grid cell was assessed each year irrespective of the indicator to be sensitive for the fishing activity by vessels using the respective gear group, index 1 and index 2 provide the same average scoring. Using this weight allows to explore the potential of co-location or co-existence in particular if the grid cell scores significantly lower in index 2 than in index 1, is an indication that the grid cell is of importance for the fishing industry but maybe not in each year. The weighted categorical numbers from 1-5 were summed up for each gear group and grid cell and a 3-years (2018-2020), 5-years (2016-2020) and 9- years (2012-2020) average for each of the indicators prepared as outputs. Resulting maps can be found in Appendix 6.2 (Sensitivity index 2).

The context-providing layers were summarised by providing a 3-years (2018-2020), 5-years (2016-2020) and 9- years (2012-2020) average for each of the indicators as final outputs. Maps can be found in the Appendix, 6.2. To make these layers publicly available, all grid cells in which less than 3 vessels were active were suppressed for the 3- and 5-year average, but in agreement with fisheries representatives in the PAG, in the outputs of the 10 years average is presented without any further suppressing undertaken as the commercial risk to identify individual fishing vessels was considered to be rather low.

Table 5: Overview of indicators collated into the sensitivity index or classified as context providing information.

Indicator 1 (Business impact)	Indicator 2 (Business concentration)	Indicator 3 (Site specificity)	Indicator 4 (Substitutability)	Indicator 5 (Inter-annual variability)	Indicator 6 (Seasonal behaviour)
a) Number of vessels with significant proportion of annual revenues	a) Concentration of vessels (HHI) for vessel sizes >=12m	a) Value of TAC species which are only harvested in a small number of grid cells.	a) Average catch concentration (HHI) of TAC species of vessels harvesting the grid cell.	a) Number of years grid cell was harvested in the last decade	a) Number of months the grid cell was harvested in average in the last decade
b) Proportion of vessels with significant proportion of annual revenues in the grid cell of all vessels active	b) Landings value weighted by vessel concentration (HHI) split for vessel sizes >=12m	b) Fraction of landing values obtained by TAC species	b) Concentration (HHI) of gear groups harvesting the grid cell.	b) Standard deviation of annual landings values	b) Standard deviation of long-term average monthly landings values

Colour symbols: Green –indicators collated into the Sensitivity Index 1 and Sensitivity Index 2; Blue – context providing spatial data layers.

4. Conclusion and discussion

This report outlines how sensitivity indicators were derived in discussion with members of the project advisory group to capture the sensitivity of an area to the fishing industry. The focus of the work is primarily to capture the economic impact of marine developments on the fishing industry and to provide evidence which can be used to support consent discussions between offshore wind operators and fishing industry representatives. Addressing concerns from representatives of the two industries as well as government agencies, by developing these indicators should allow for acceptance of these indicators and potential future use.

In practical terms, these indicators can be generated based on fisheries-dependent data for each year and each gear group. Depending on what data is available on the spatial resolution required to assess the sensitivity of the fishing location, the results can vary and emphasize for example some fleet segment more than others. In the example provided, only the vessels over 12-m length were included as well as landings in some cases restricted to species managed by quota. Hence, extending the data to other species or additional vessel length, will change the resulting maps. However, irrespective of which criteria are used, the indicators provide decision makers with additional information and understanding on the importance of fishing locations in a more comprehensive manner than using only landing values generated in the area.

In future work, the indicators are to be implemented by using the data generated in WP2 of the project on fishing location. Merged with the logbook data provided by MMO the higher resolution of data should provide a more detailed picture on sensitive fishing locations. Moreover, while the indicators and the application example were checked on any occurring sensitivity towards assumptions within the indicator and compilation of the index, a more comprehensive assessment on the uncertainty is still outstanding.

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6. Appendix

To visualize the indicators and how they would capture different aspects of economic sensitivity of the fishing location than applying landing values, the indicators were implemented for UK-flagged vessels harvesting the UK-EEZ using VMS data joined with fishing activity reports provided by MMO for the years 2012-2020. The next section will show example maps of the indicators (1a-6b). As example serves demersal trawl activity in 2019, fishing activity using hooks and lines in 2018 and pelagic trawl in 2020. These examples and their location were randomly chosen and only serves to visualize the difference in capturing the sensitivity assessment using a different metrics than landing values. The second section shows the combined indicators as well as the context-providing indicators in the version they will be implemented in the webtool, hence will be made publicly available.

6.1. Example maps of individual indicators in comparison to reported landing values based on data derived from the Vessel Monitoring System (VMS) and logbook data from MMO

6.1.1 UK-flagged vessels using gear classified as demersal trawl within the UK EEZ

Demersal trawl, 2019

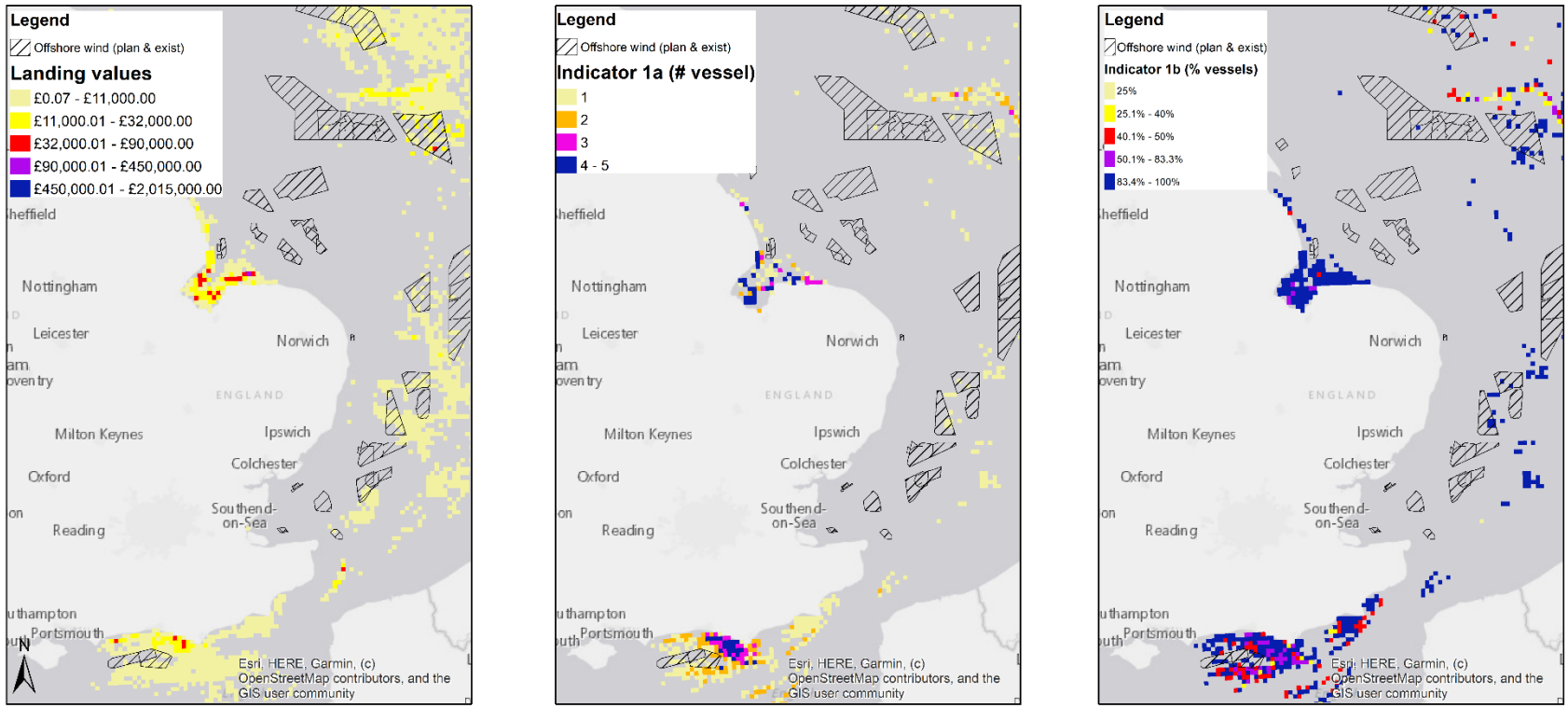

Figure 3: Example map of indicator 1a and 1b in comparison to landing values for vessels using demersal trawl in 2019

Demersal trawl, vessel length 12-15m, 2019

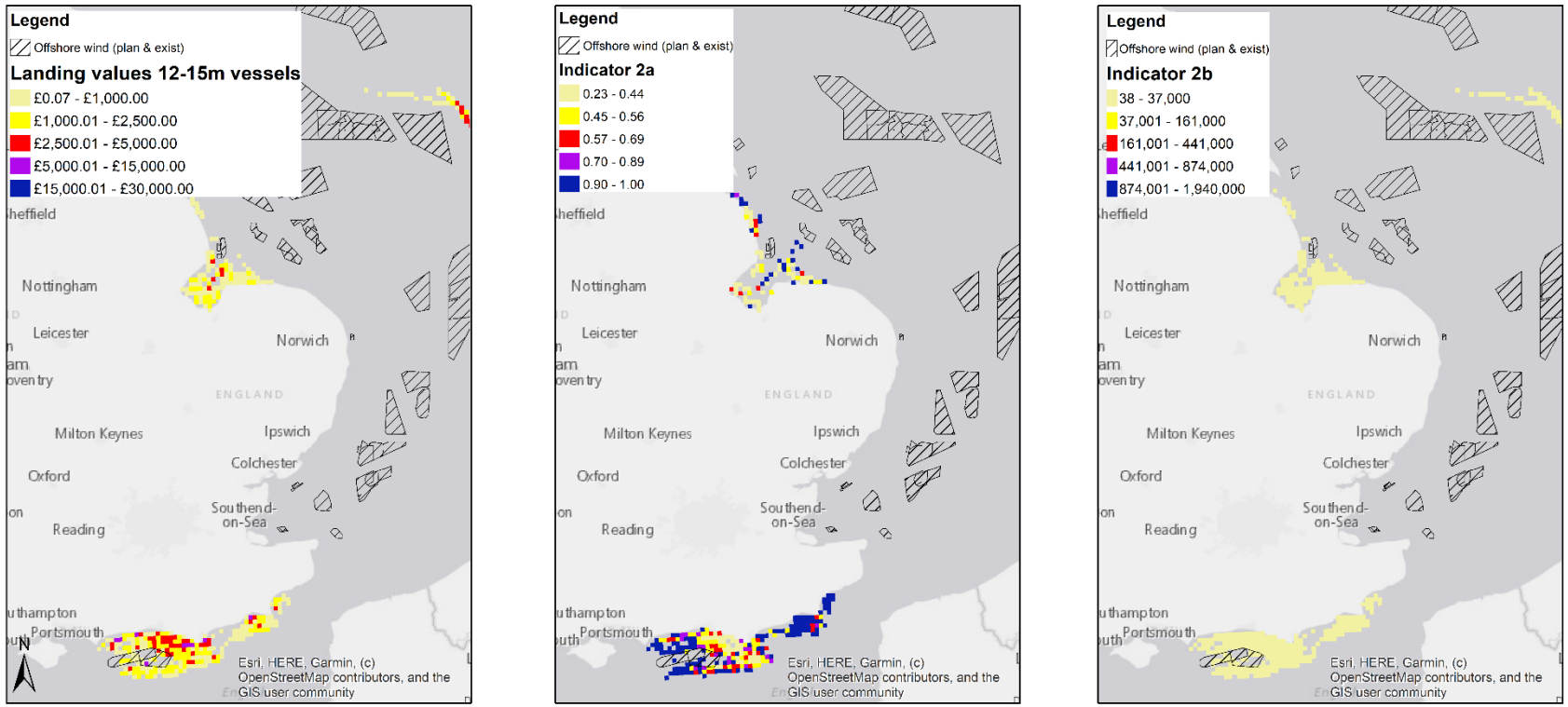

Figure 4: Example map of indicator 2a and 2b in comparison to landing values for vessels of lengths 12-15 metres using demersal trawl in 2019

Demersal trawl, TAC species, 2019

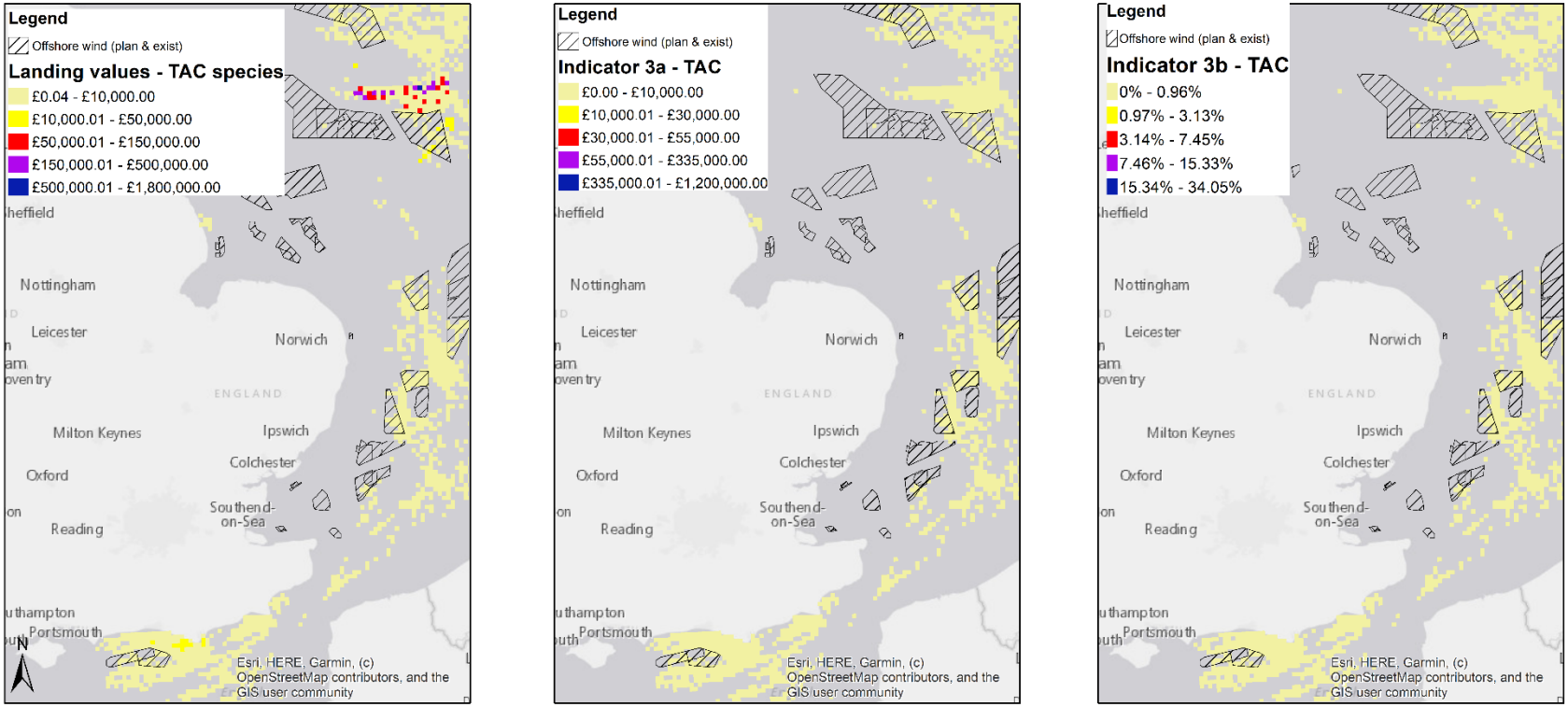

Figure 5: Example map of indicator 3a and 3b in comparison to landing values for vessels using demersal trawl harvesting species managed by quota in 2019

TAC species, 2019
Demersal gear, except 4b - all gears

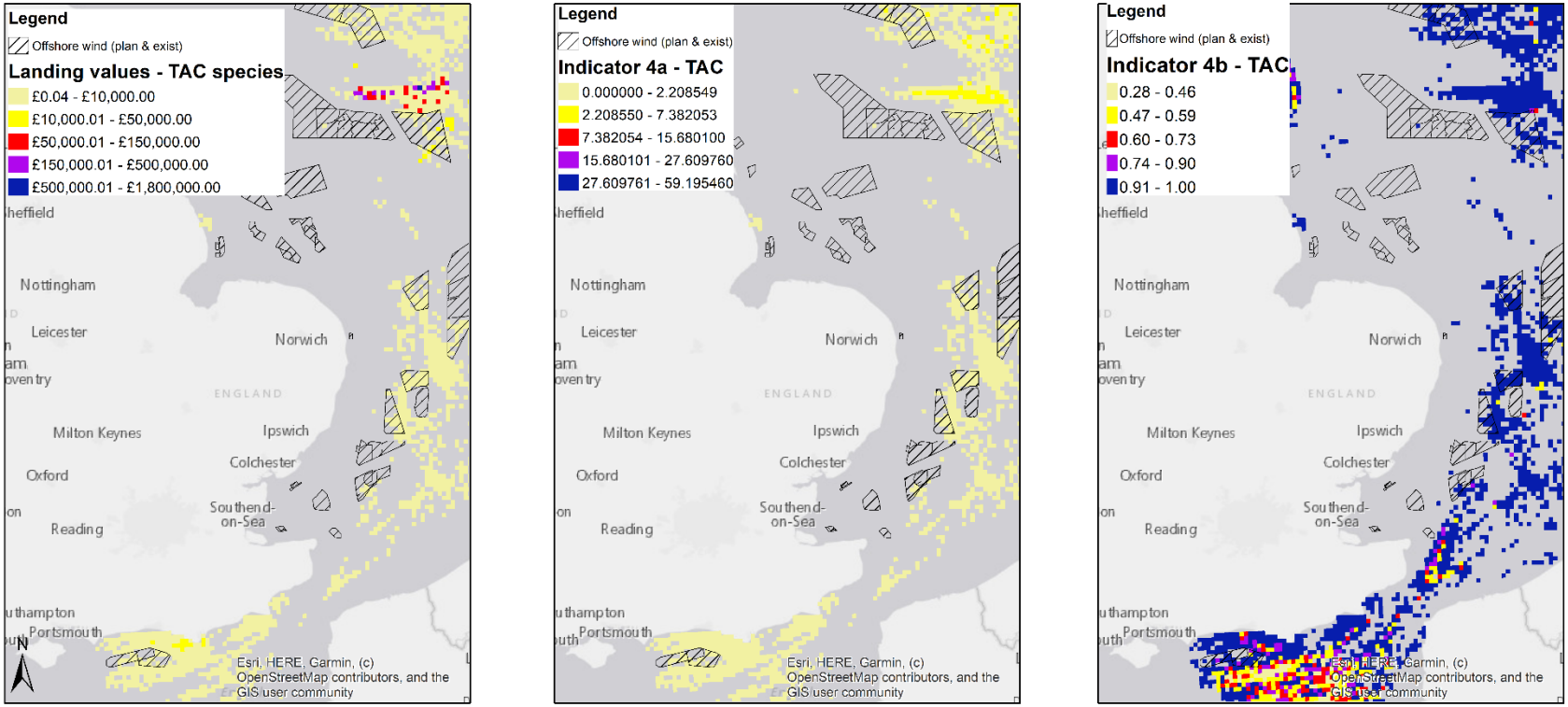

Figure 6: Example map of indicator 4a in comparison to landing values for vessels using demersal trawl in 2019 and indicator 4b (gear concentrations in 2019 – all gears)

Demersal trawl, 2012-2020

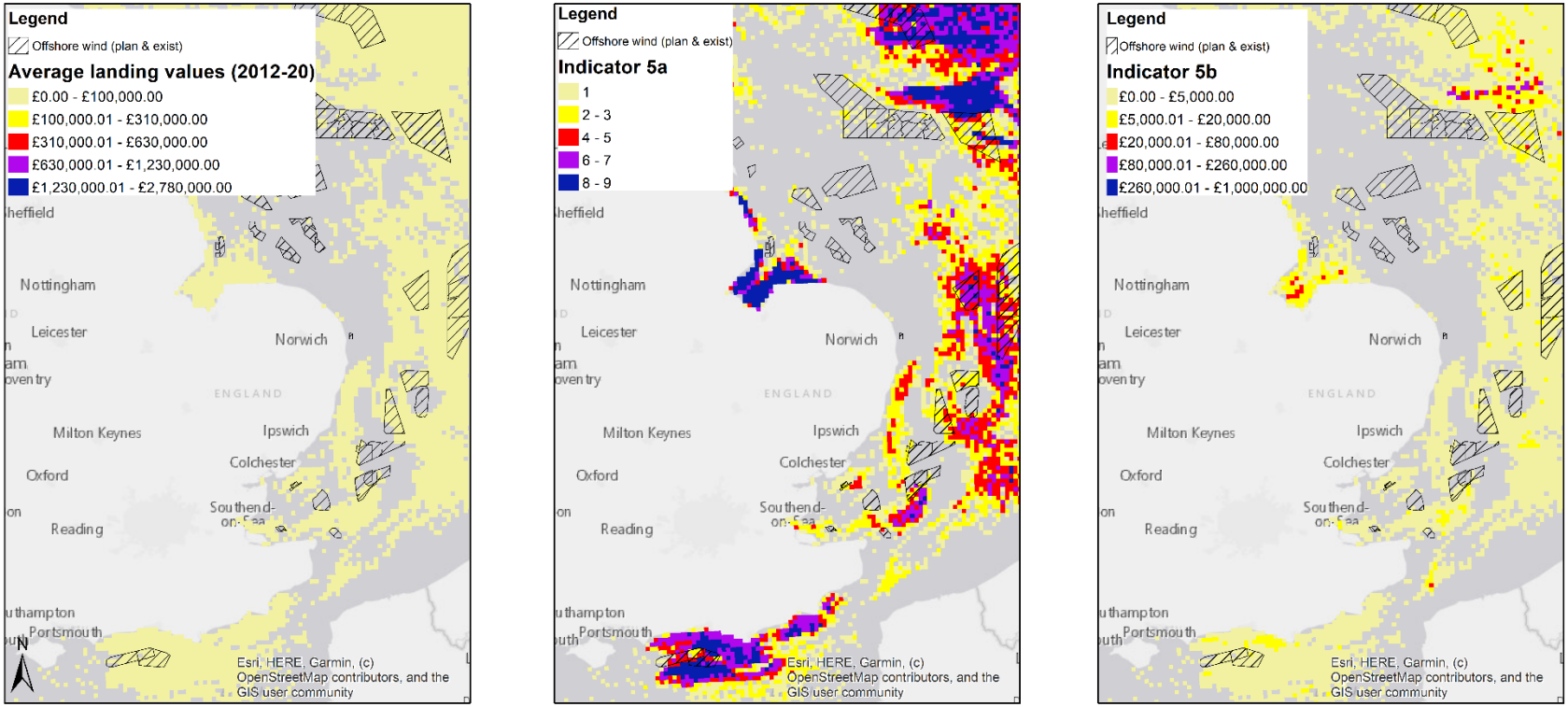

Figure 7: Example map of indicator 5a and 5b in comparison to long-term average annual landing values for vessels using demersal trawl (2012-2020)

Demersal gear, 2012-2020

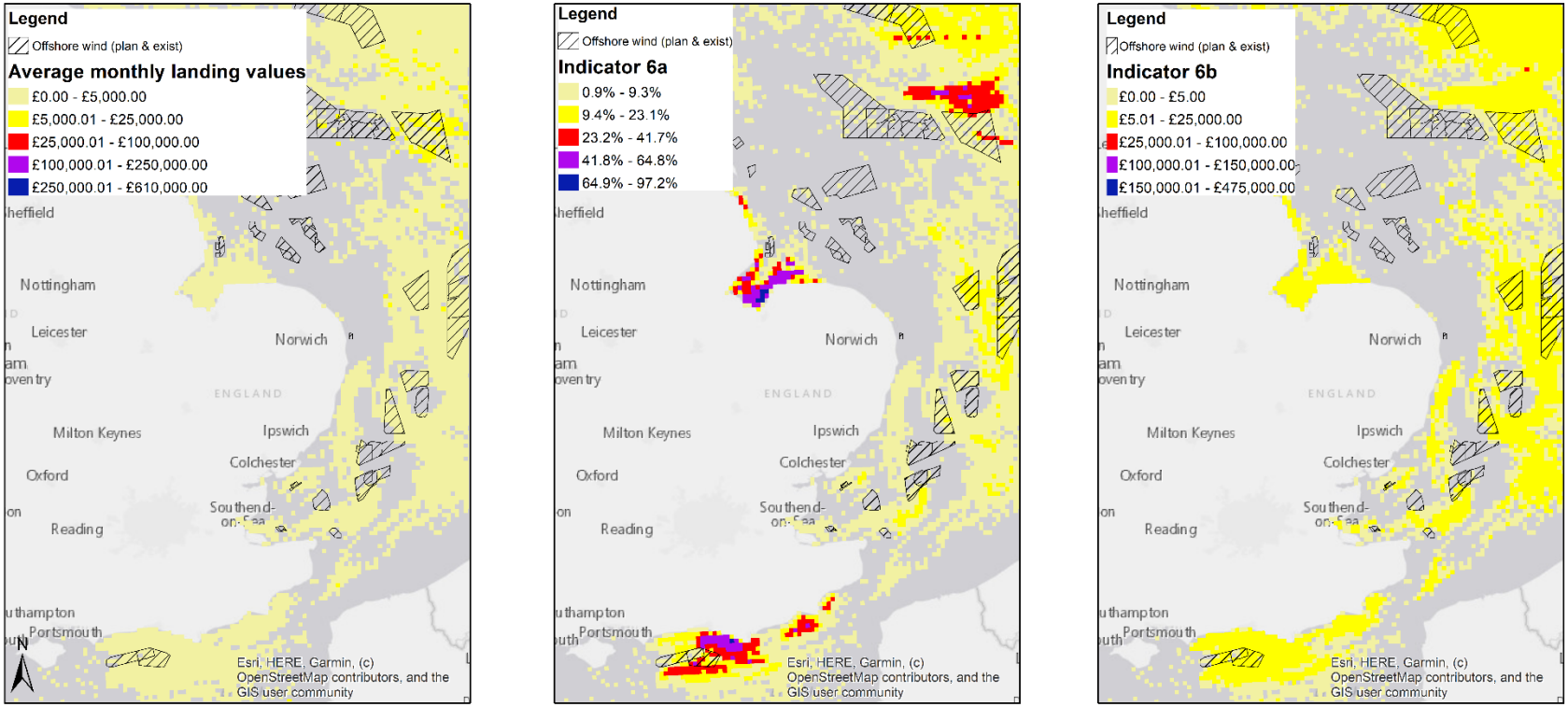

Figure 8: Example map of indicator 6a and 6b in comparison to long-term average monthly landing values for vessels using demersal trawl (2012-2020)

6.1.2 UK-flagged vessels using gear classified as hooks and line within the UK EEZ

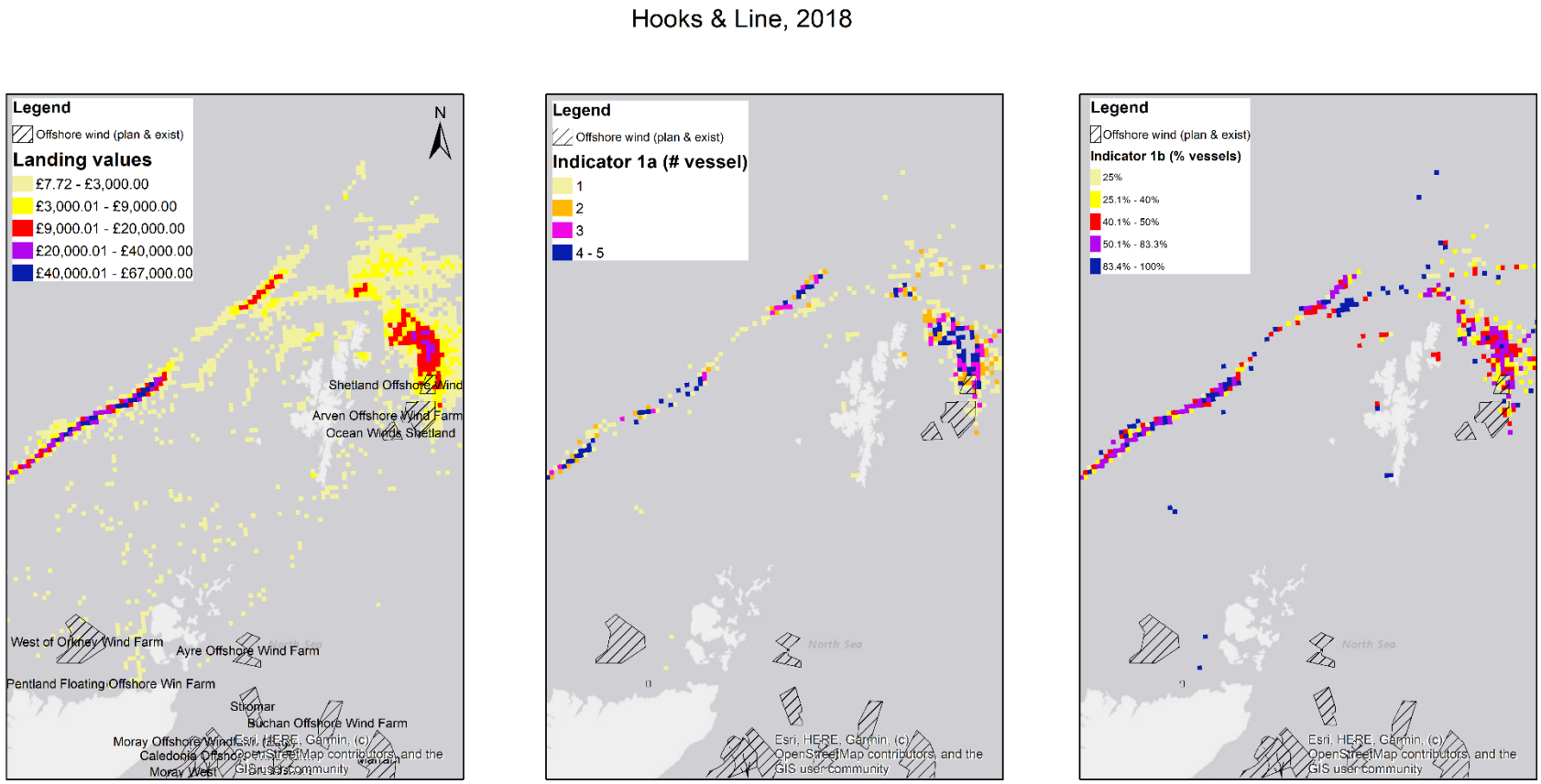

Figure 9: Example map of indicator 1a and 1b in comparison to landing values for vessels using hooks and line in 2018

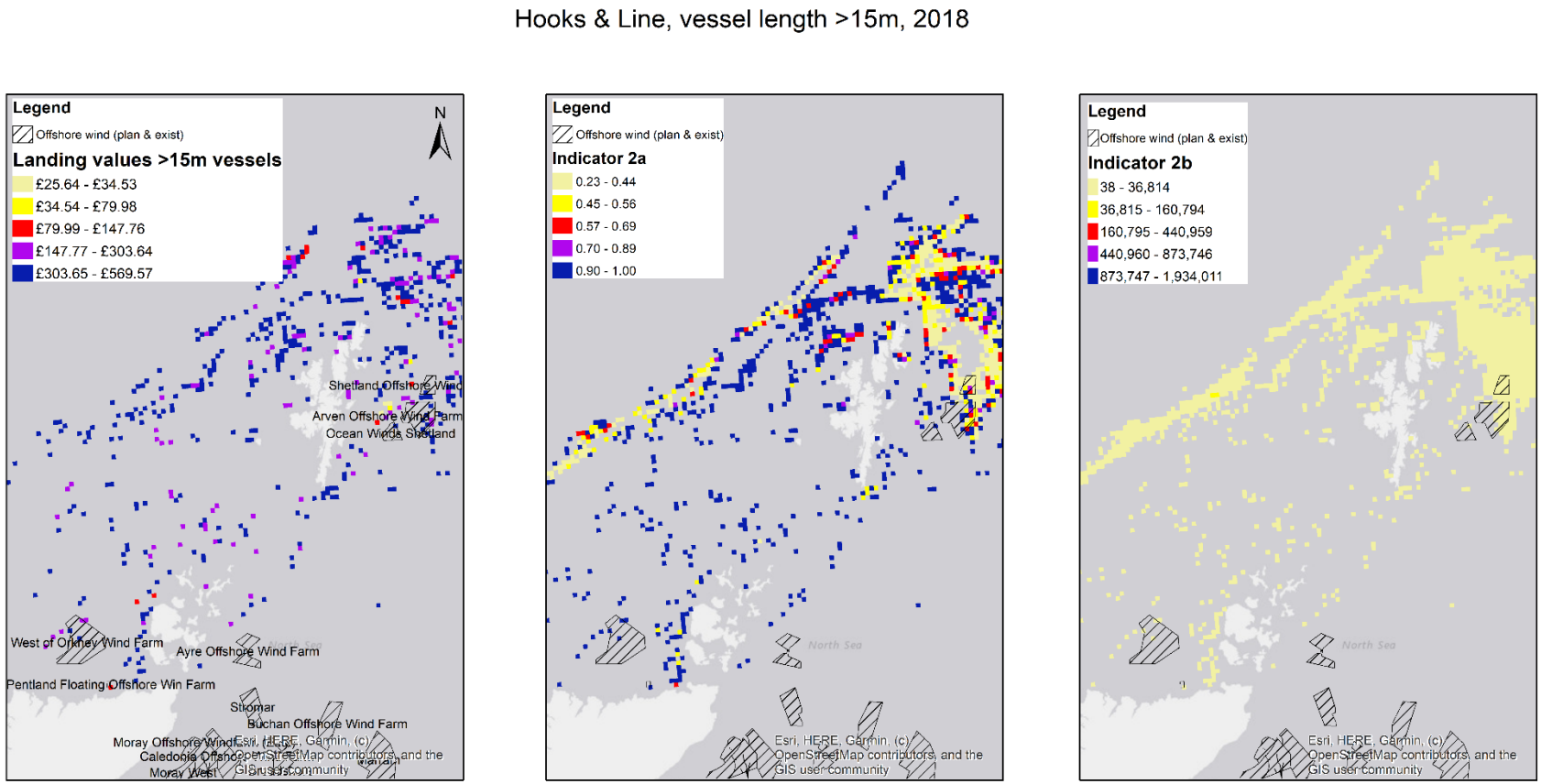

Figure 10: Example map of indicator 2a and 2b in comparison to landing values for vessels of above 15 metres lengths using hooks and line in 2018

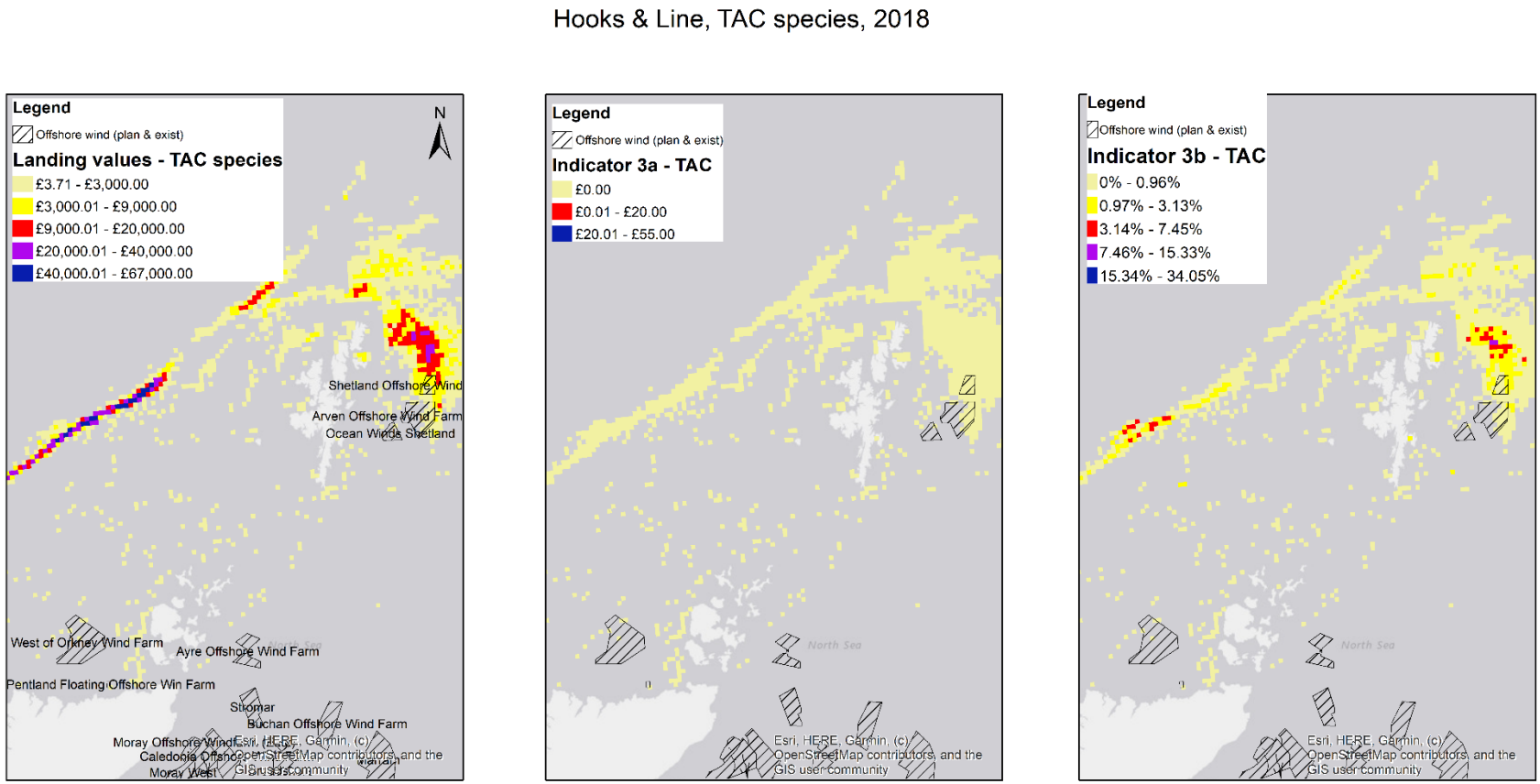

Figure 11: Example map of indicator 3a and 3b in comparison to landing values for vessels using hook and line harvesting species managed by quota in 2018

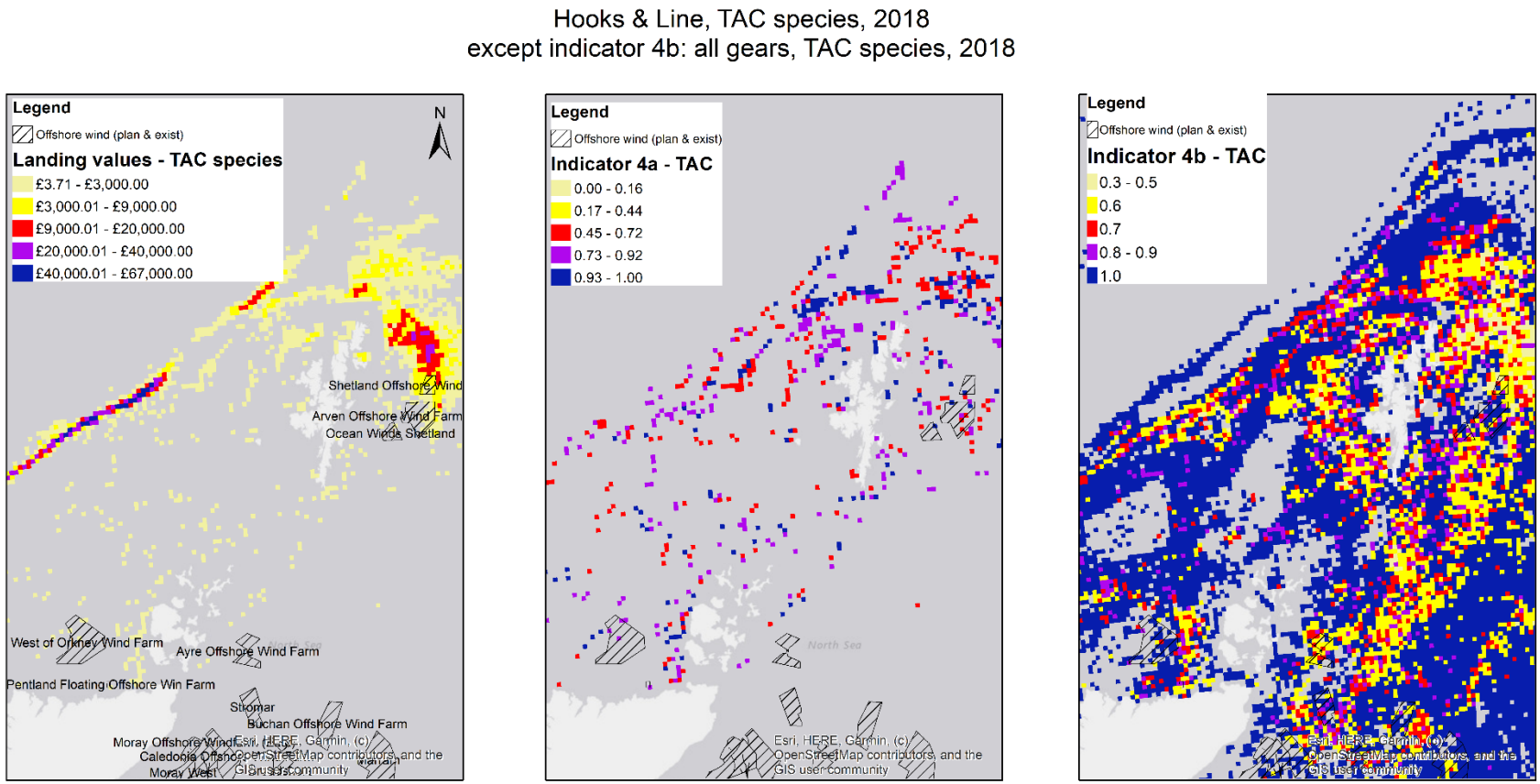

Figure 12: Example map of indicator 4a in comparison to landing values for vessels using hooks and line in 2018 and indicator 4b (gear concentrations in 2018 – all gears)

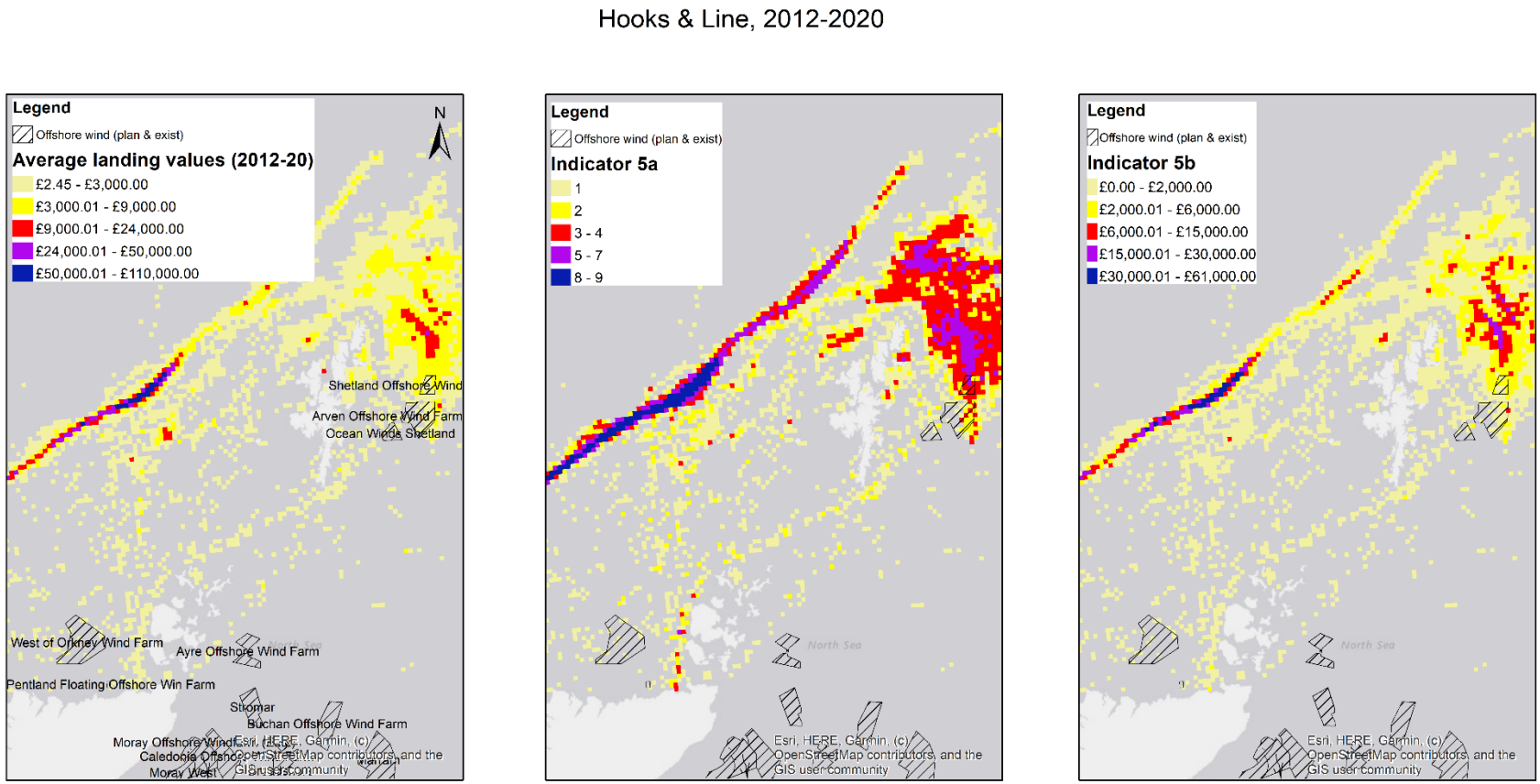

Figure 13: Example map of indicator 5a and 5b in comparison to long-term average annual landing values for vessels using hooks and line (2012-2020)

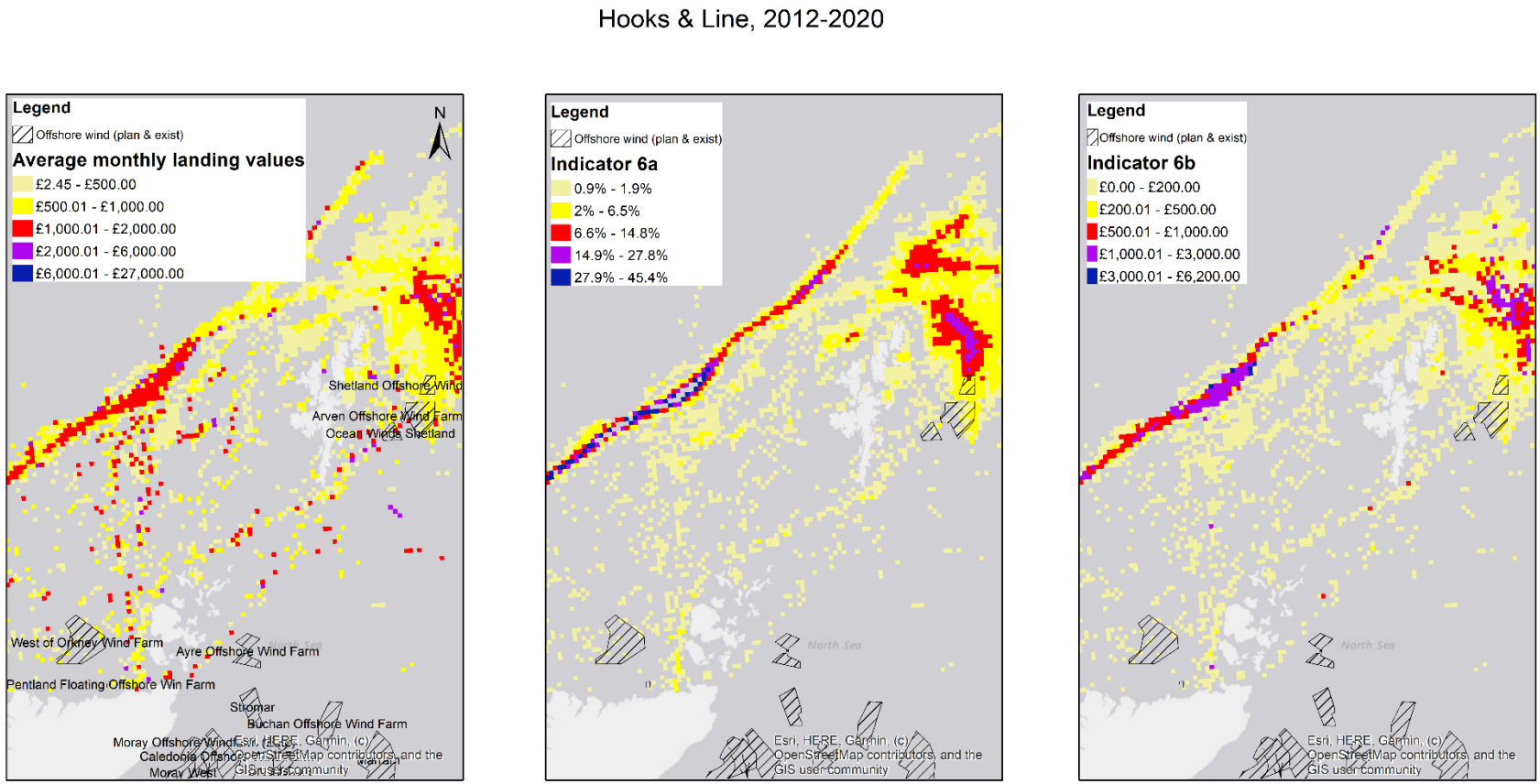

Figure 14: Example map of indicator 5a and 5b in comparison to long-term average monthly landing values for vessels using hooks and line (2012-2020)

6.1.3 UK-flagged vessels using gear classified as pelagic gear within the UK EEZ

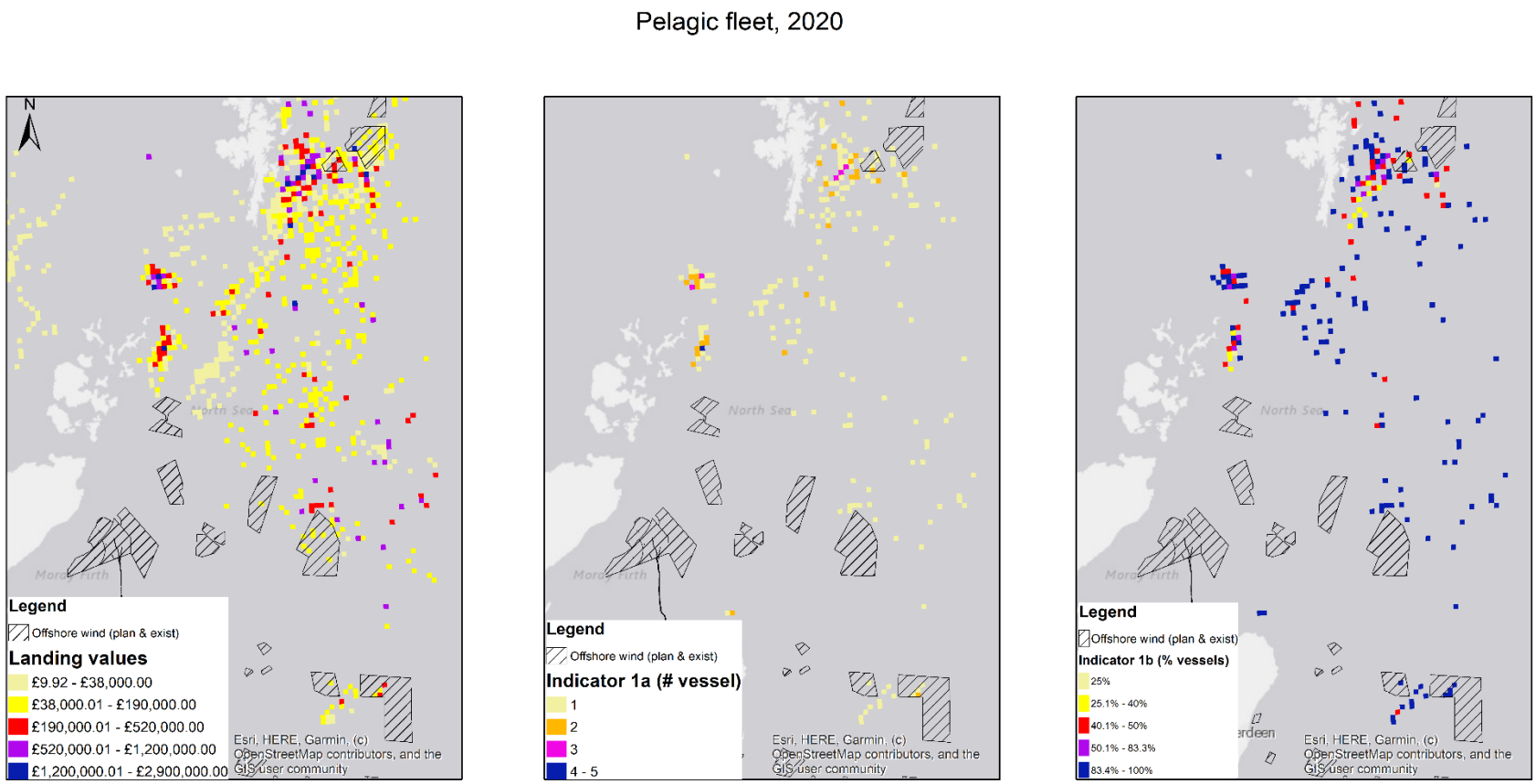

Figure 15: Example map of indicator 1a and 1b in comparison to landing values for vessels using pelagic gear in 2020

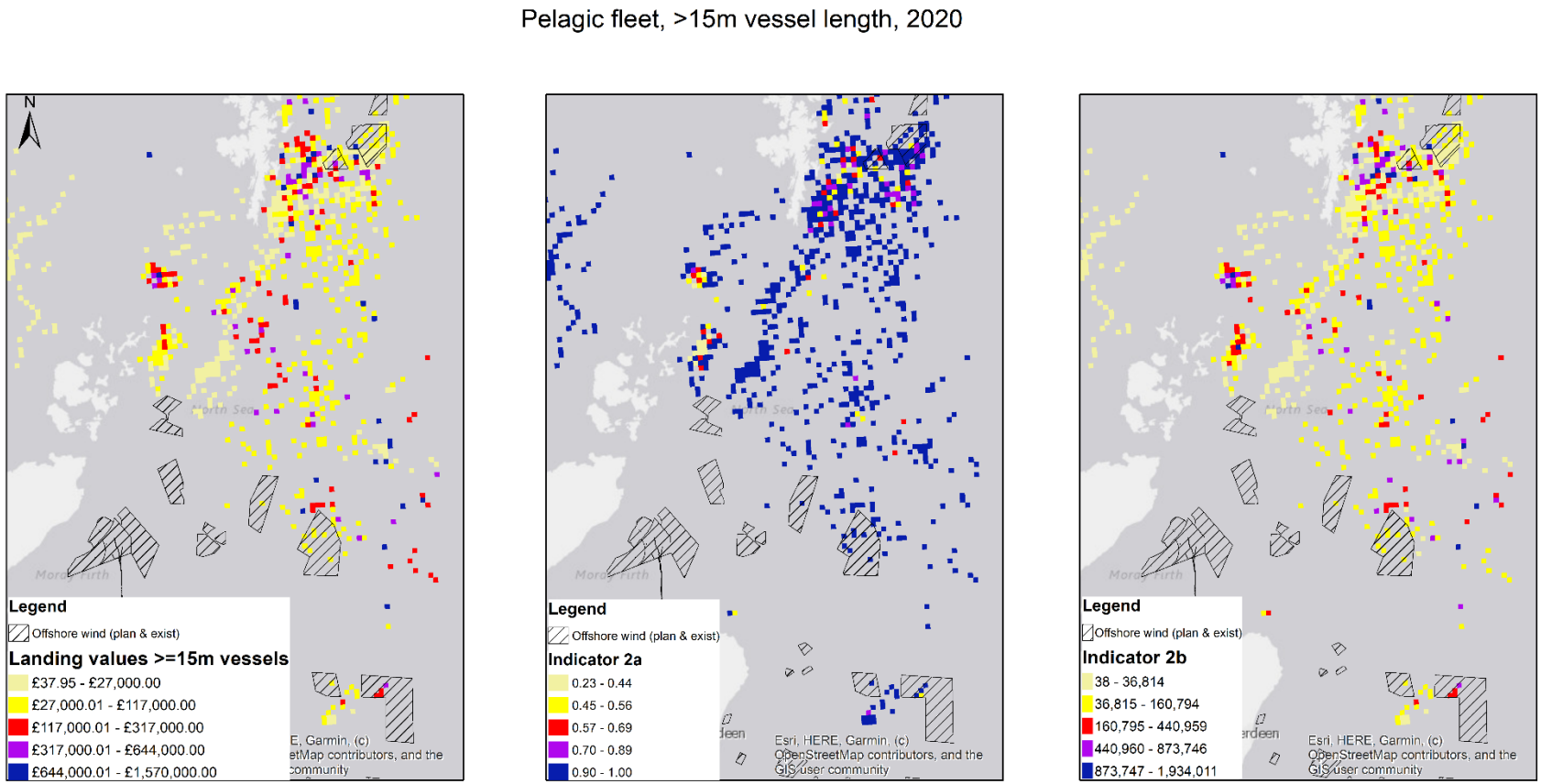

Figure 16: Example map of indicator 2a and 2b in comparison to landing values for vessels of above 15 metres lengths using pelagic gear in 2020

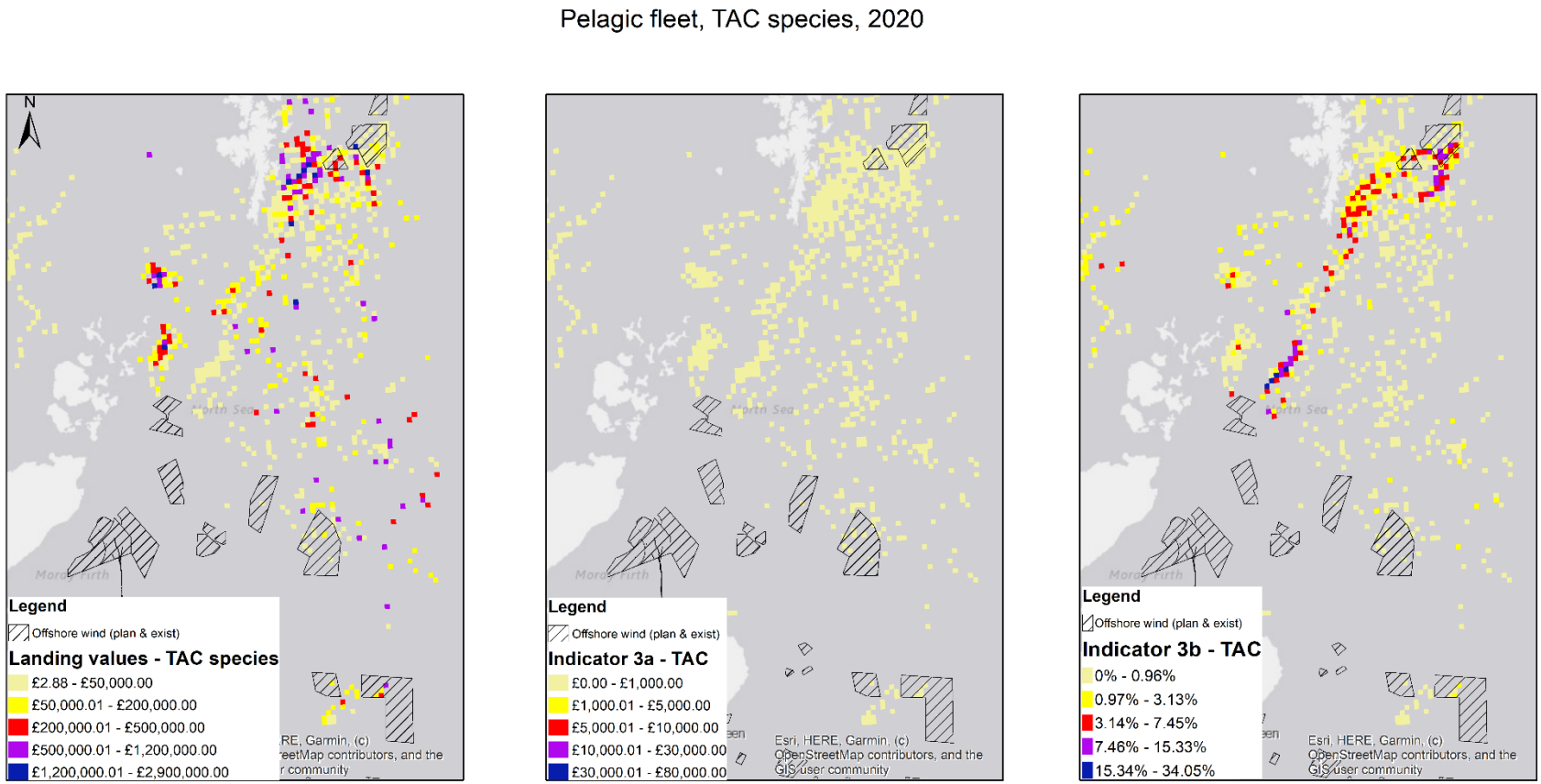

Figure 17: Example map of indicator 3a and 3b in comparison to landing values for vessels using pelagic gear harvesting species managed by quota in 2020

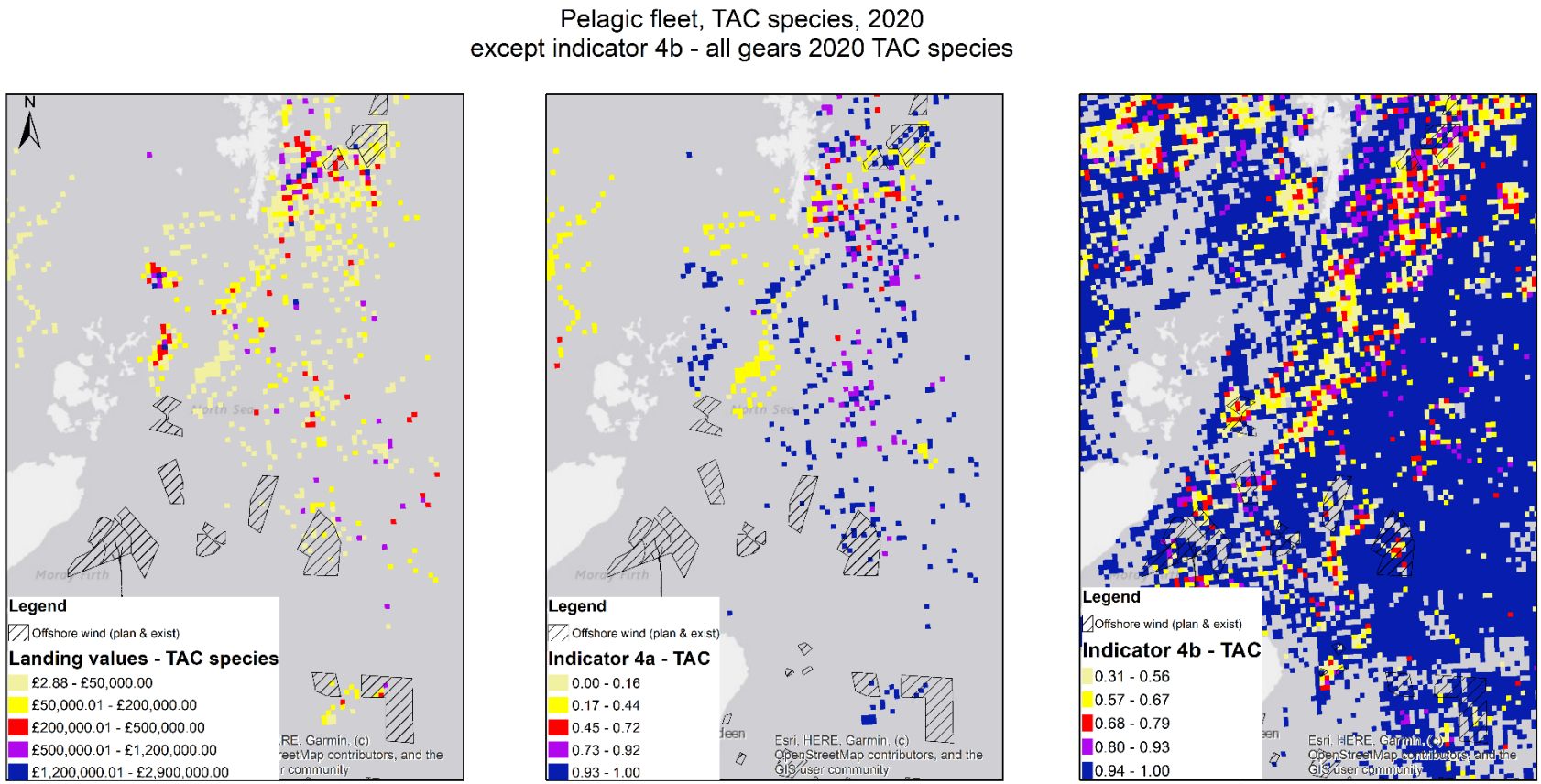

Figure 18: Example map of indicator 4a in comparison to landing values for vessels using pelagic gear in 2020 and indicator 4b (gear concentrations in 2020– all gears)

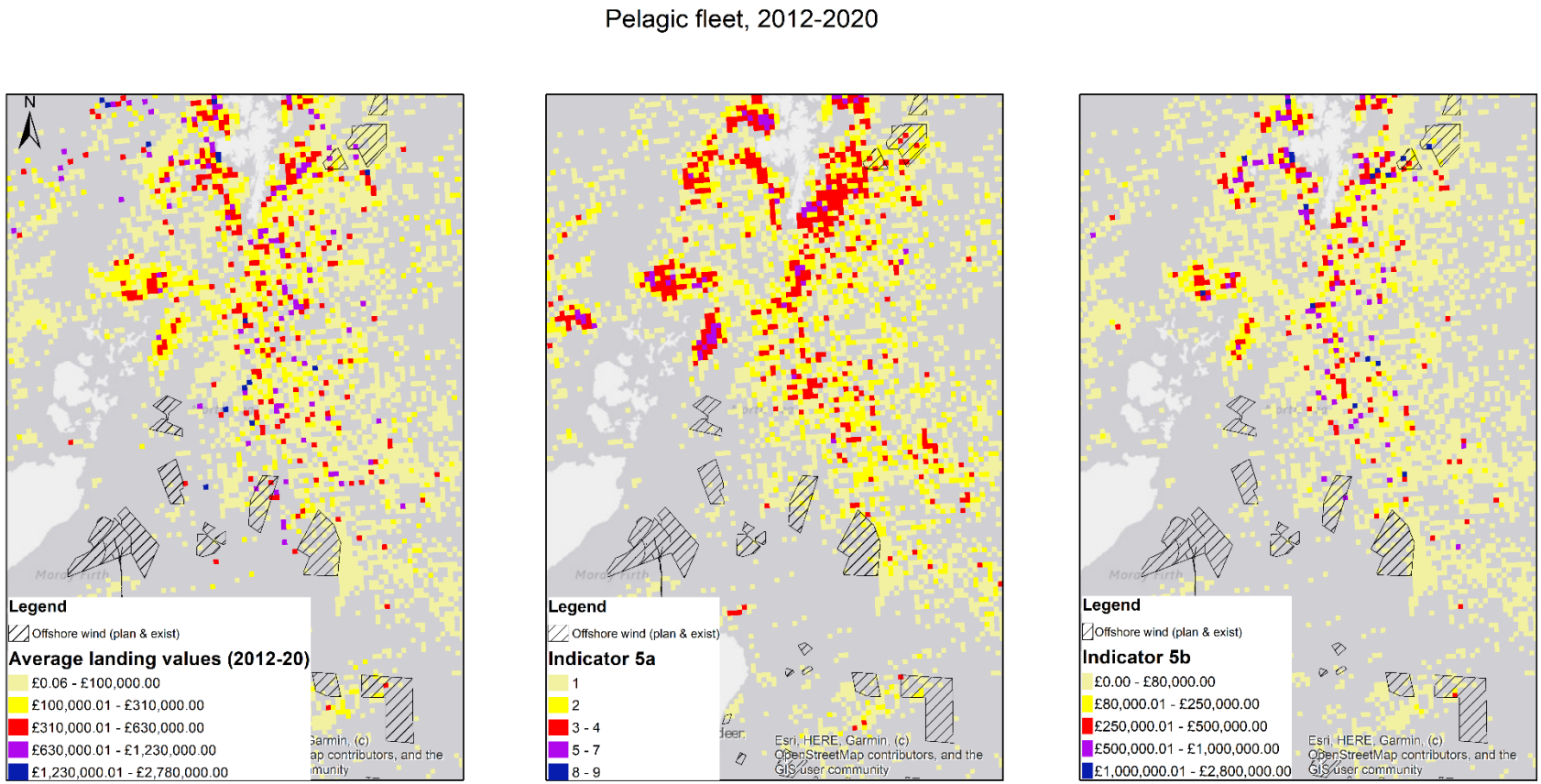

Figure 19: Example map of indicator 5a and 5b in comparison to long-term average annual landing values for vessels using pelagic gear (2012-2020)

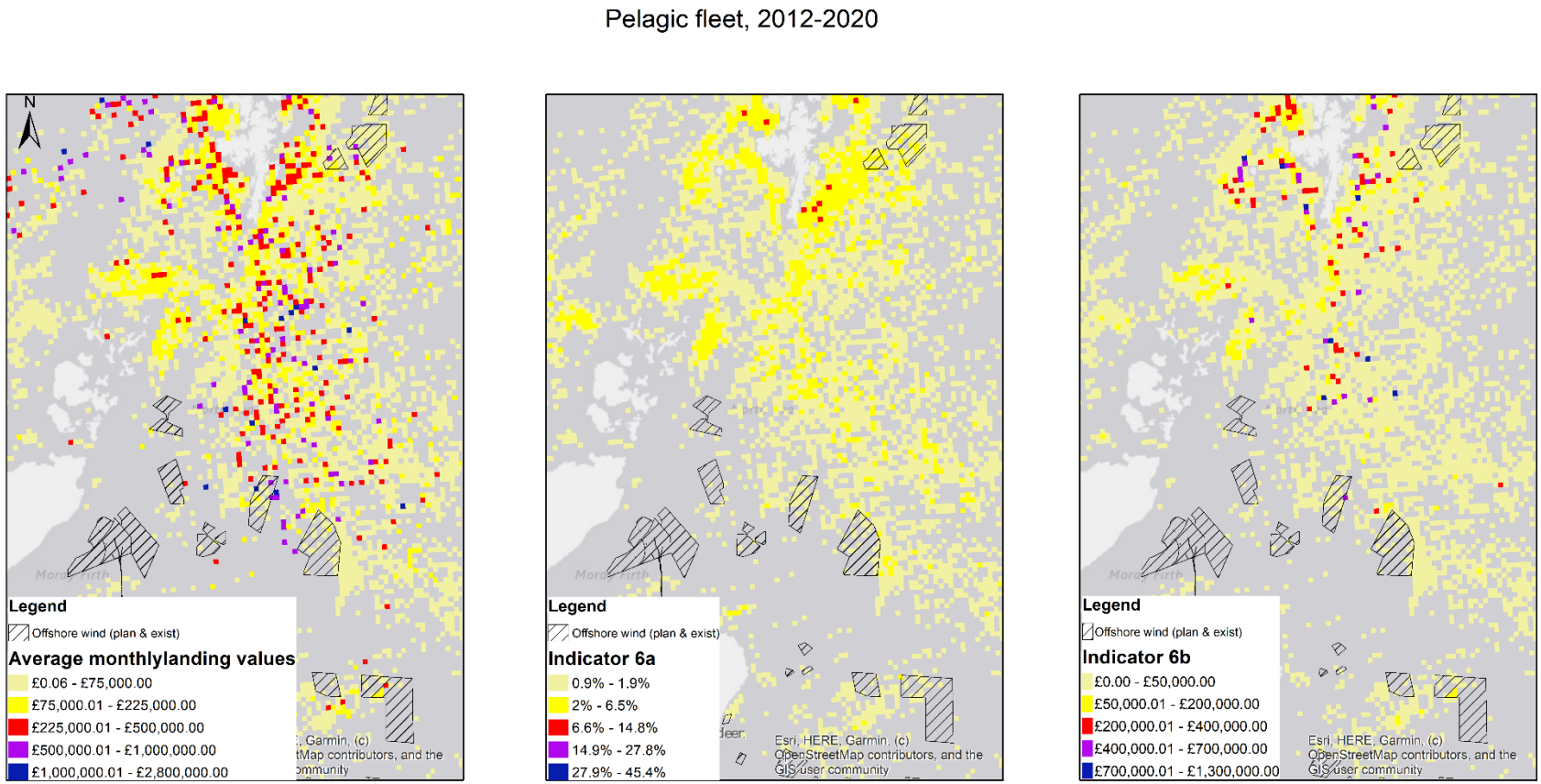

Figure 20: Example map of indicator 5a and 5b in comparison to long-term average monthly landing values for vessels using pelagic gear (2012-2020)

6.2. Example maps for the combined indicators and context-providing layers as 3-, 5- and 9-years average

6.2.1 UK-flagged vessels using gear classified as demersal trawl within the UK EEZ

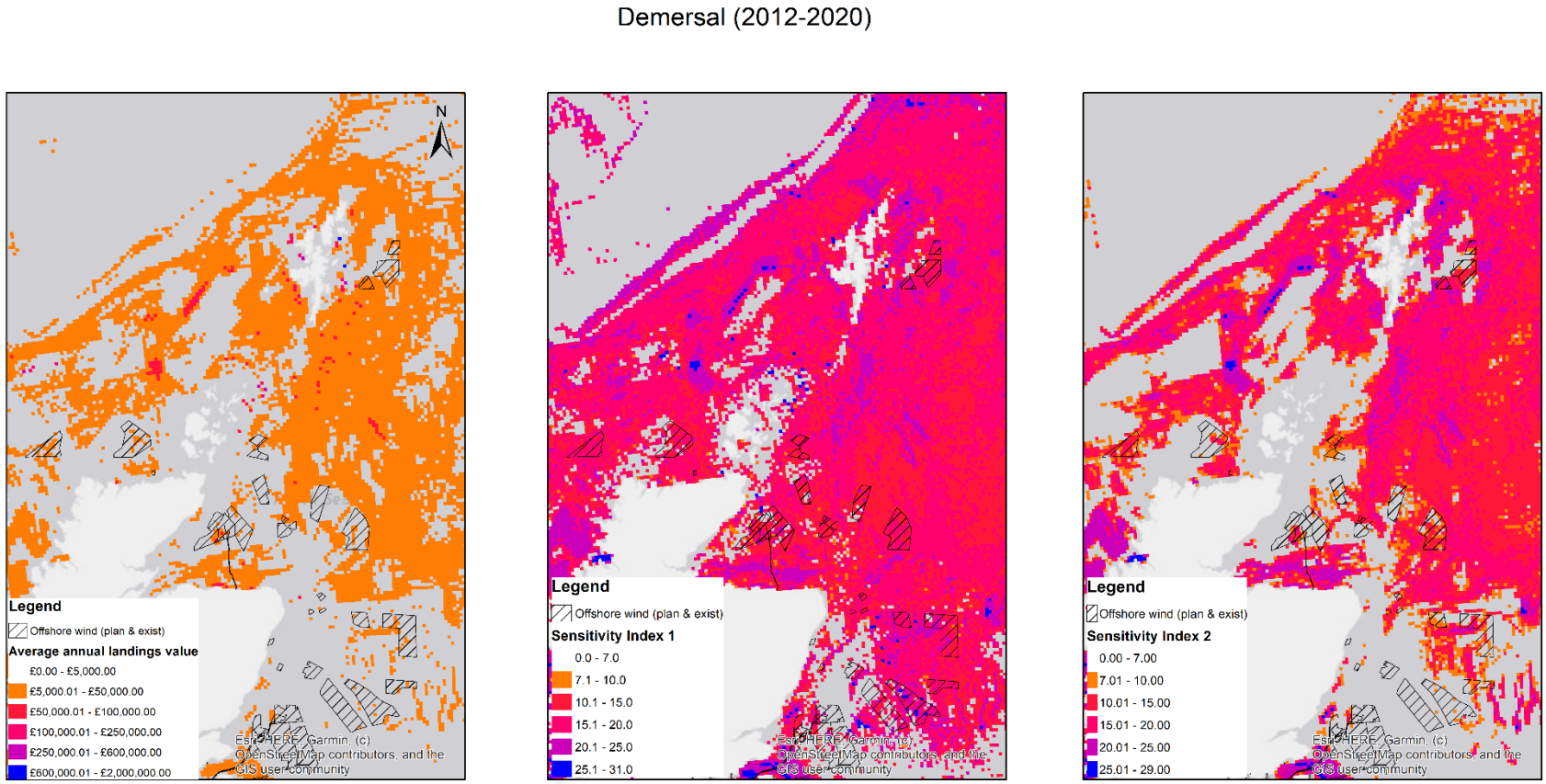

Figure 21: Sensitivity index 1 (9-years average) and index 2 (9-years average) in comparison to average annual landing values (2012-2020)

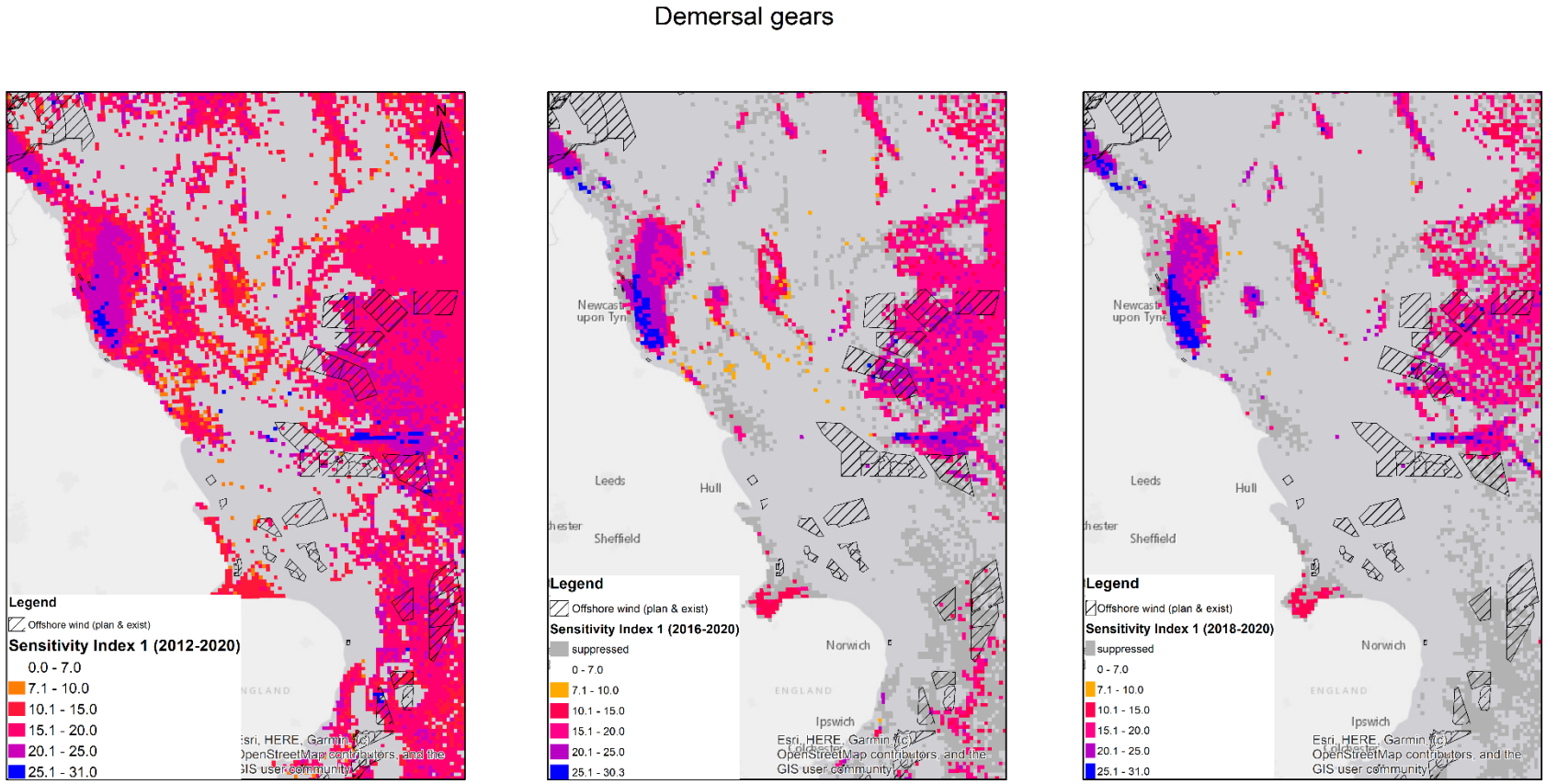

Figure 22: Sensitivity index 1 as 9-year average, 5-year average and 3-year average

Demersal

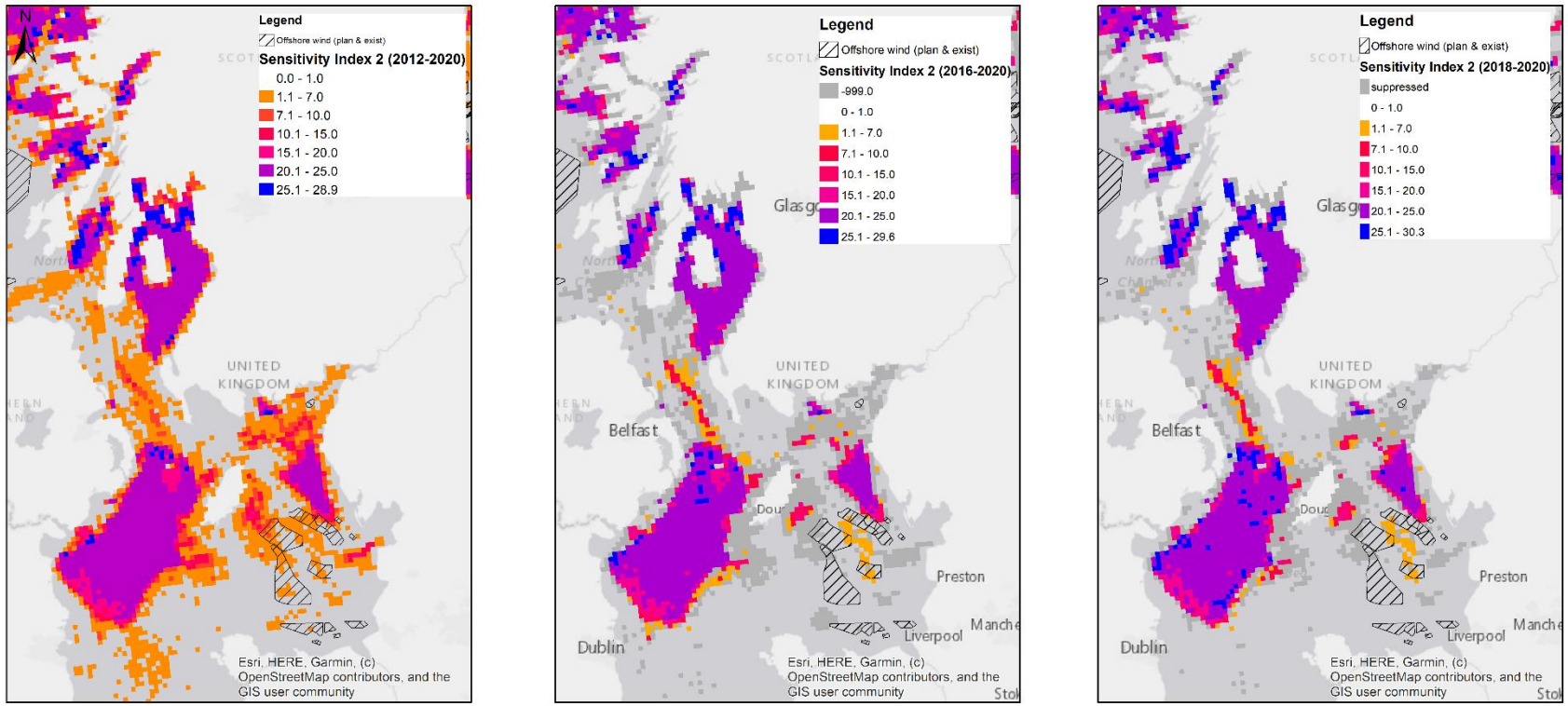

Figure 23: Sensitivity index 2 as 9-year average, 5-year average and 3-year average

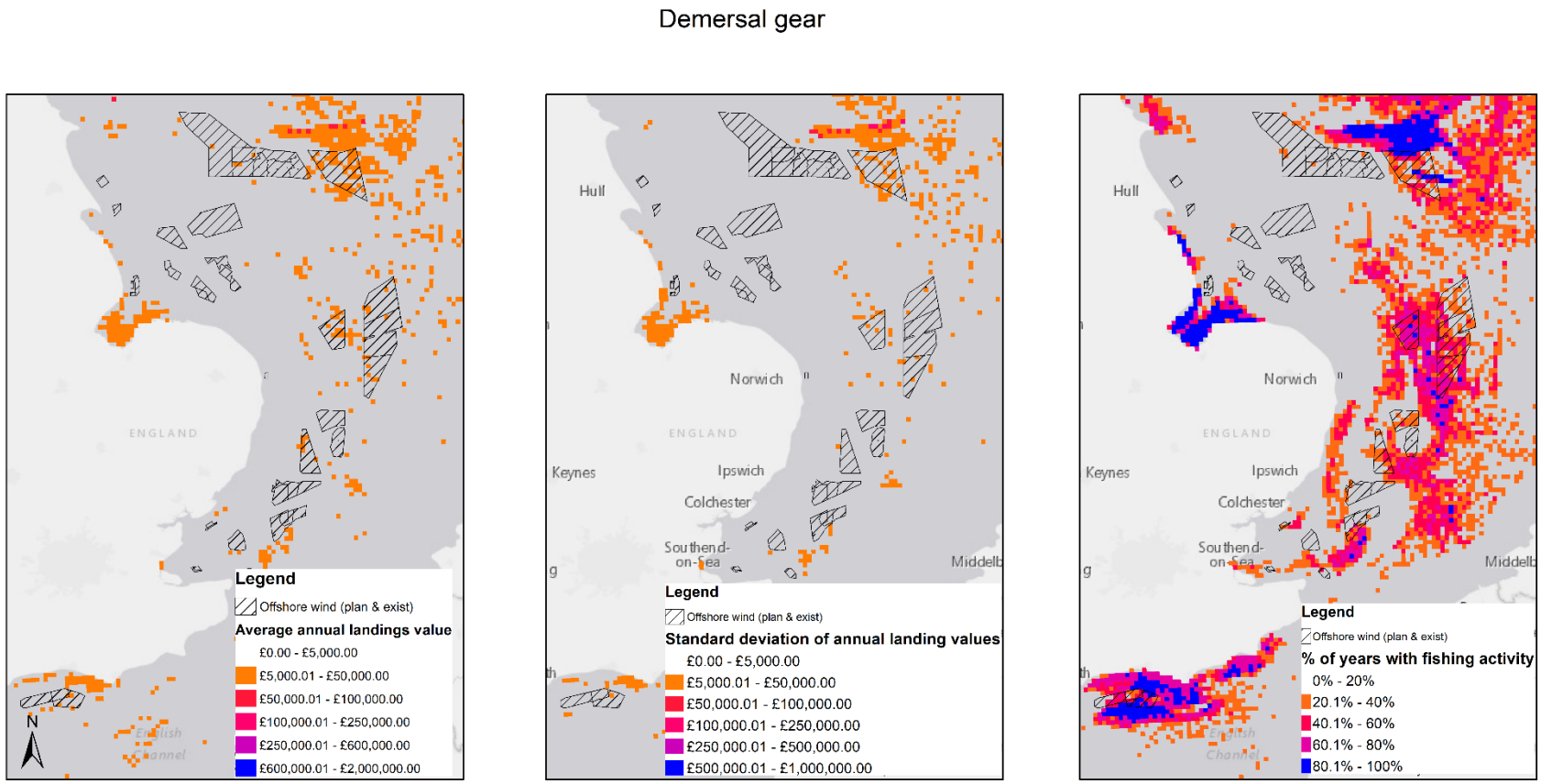

Figure 24: Example maps of Indicator 5a (Standard deviation of annual landing values) and Indicator 5b (Percentage of years the location was fished out of the 9 years here included) in comparison to long-term average annual landing values (2012-2020) for vessels using demersal gear.

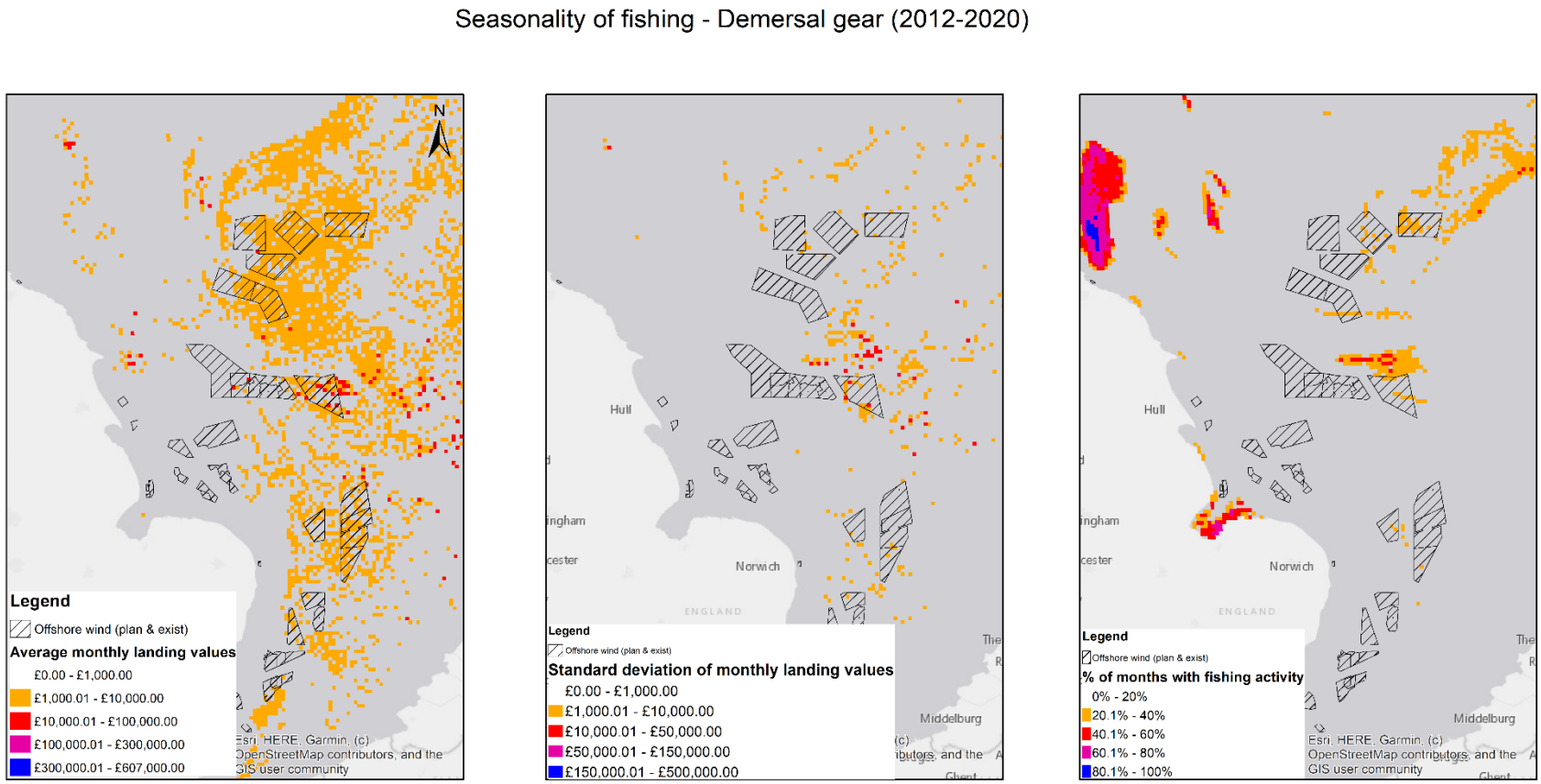

Figure 25: Example maps of Indicator 6a (Standard deviation of monthly landing values) and Indicator 6b (Percentage of months the location was fished out of the 9 years here included) in comparison to long-term average annual landing values (2012-2020) for vessels using demersal gear.

6.2.2 UK-flagged vessels using gear classified as pelagic gear within the UK EEZ

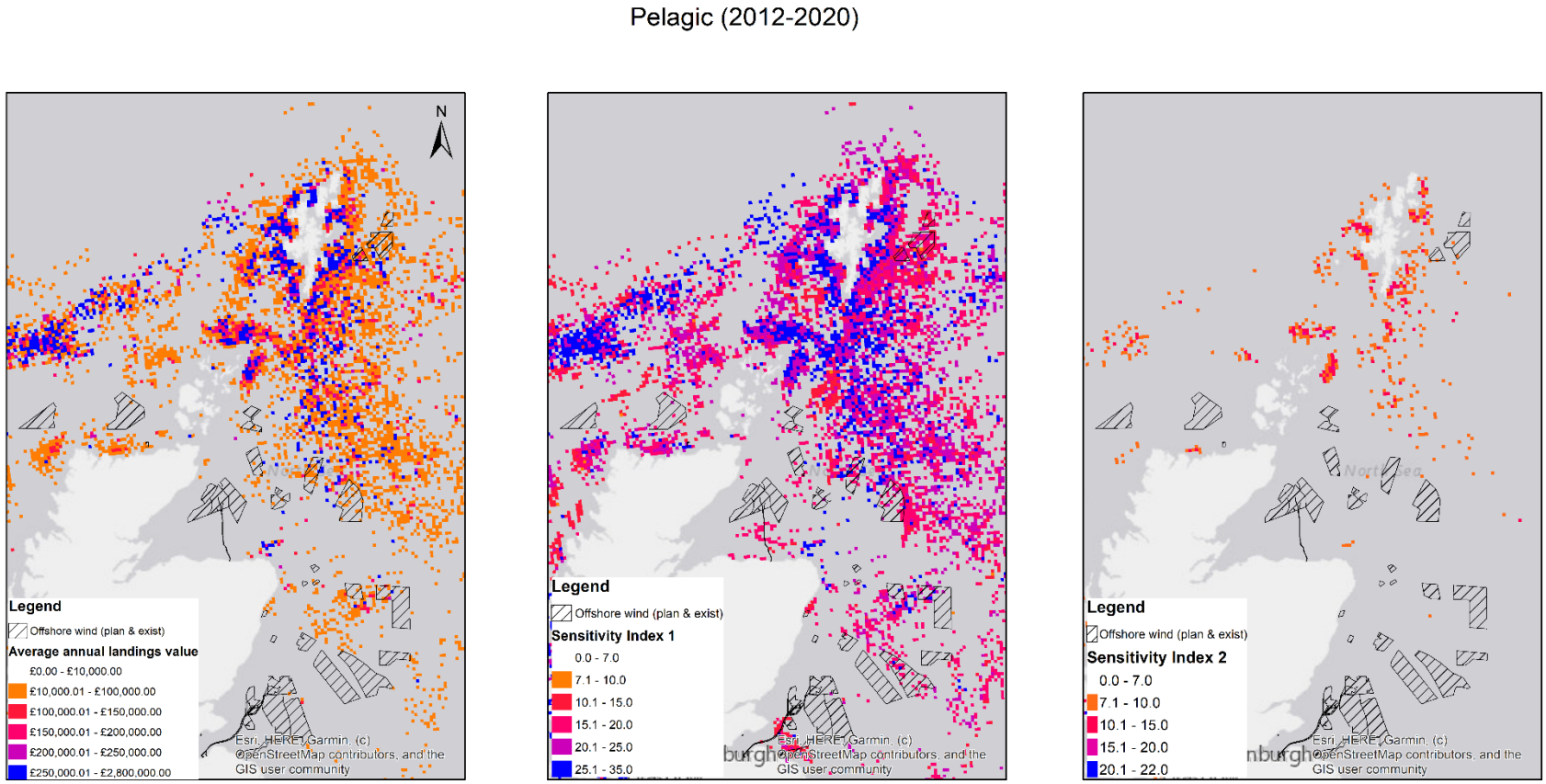

Figure 26: Sensitivity index 1 (9-years average) and index 2 (9-years average) in comparison to average annual landing values (2012-2020)

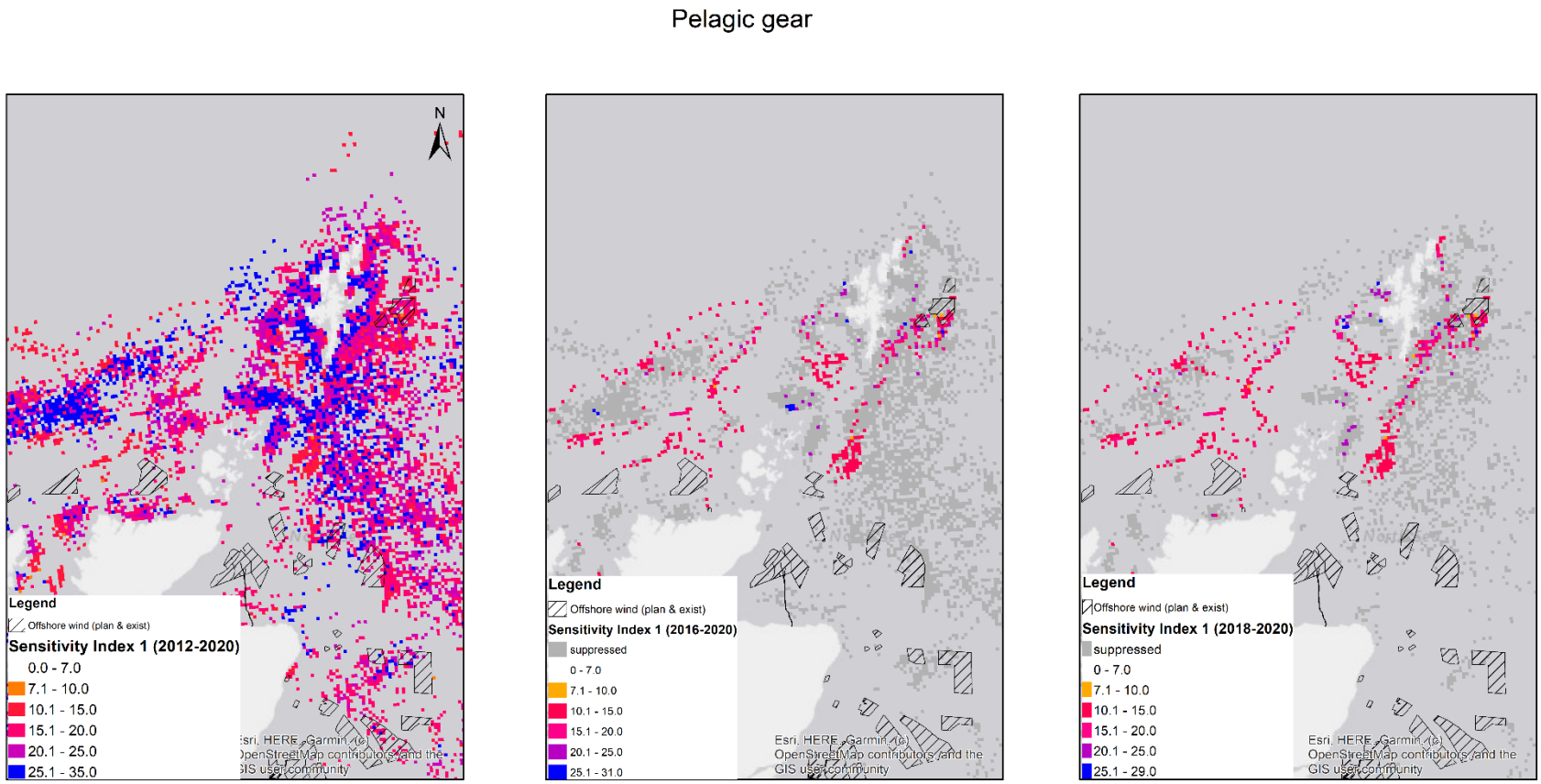

Figure 27: Sensitivity index 1 as 9-year average, 5-year average and 3-year average

Pelagic

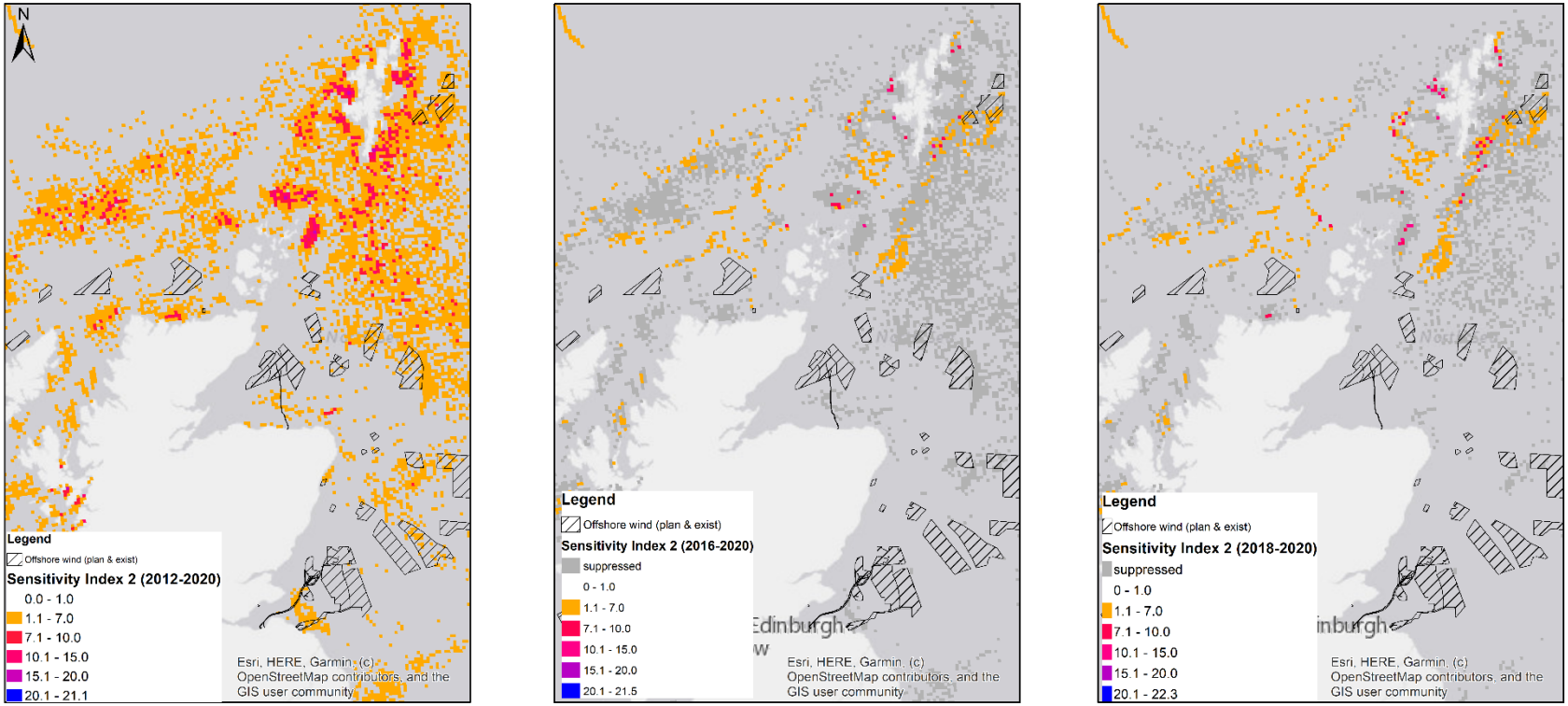

Figure 28: Sensitivity index 2 as 9-year average, 5-year average and 3-year average

Pelagic

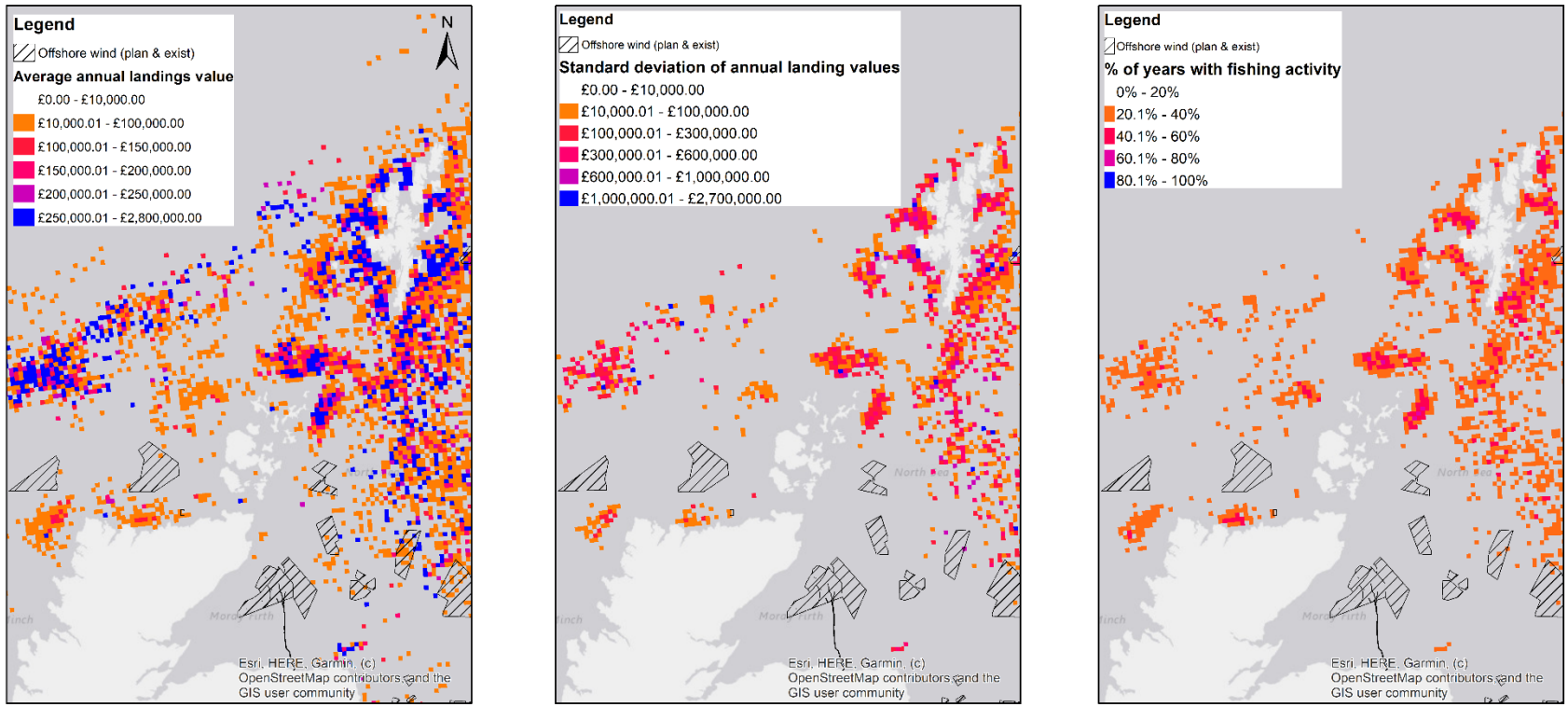

Figure 29: Example maps of Indicator 5a (Standard deviation of annual landing values) and Indicator 5b (Percentage of years the location was fished out of the 9 years here included) in comparison to long-term average annual landing values (2012-2020) for vessels using pelagic gear.

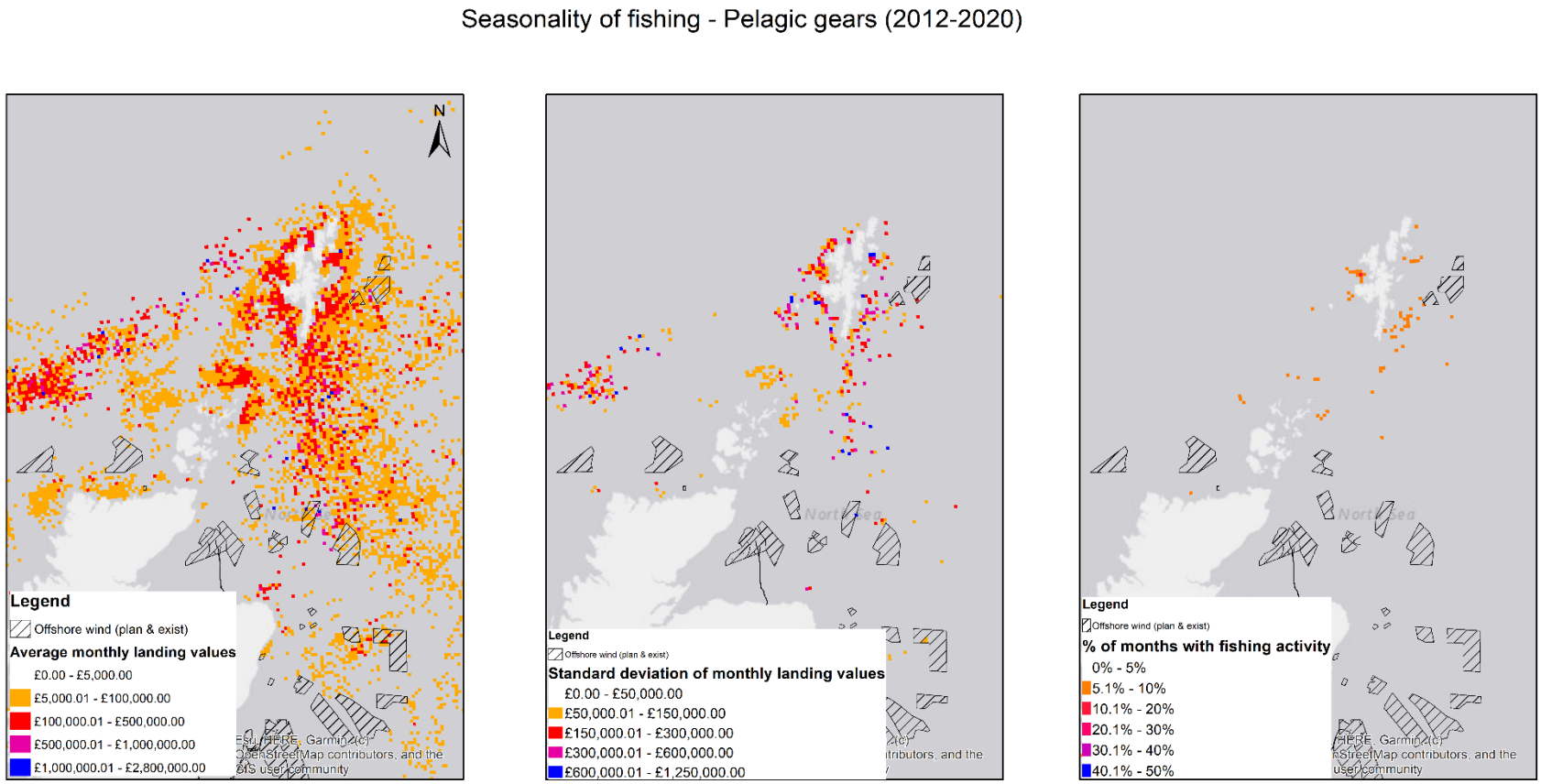

Figure 30: Example maps of Indicator 6a (Standard deviation of monthly landing values) and Indicator 6b (Percentage of months the location was fished out of the 9 years here included) in comparison to long-term average monthly landing values (2012-2020) for vessels using pelagic gear.

UK-flagged vessels using gear classified as hook and line within the UK EEZ

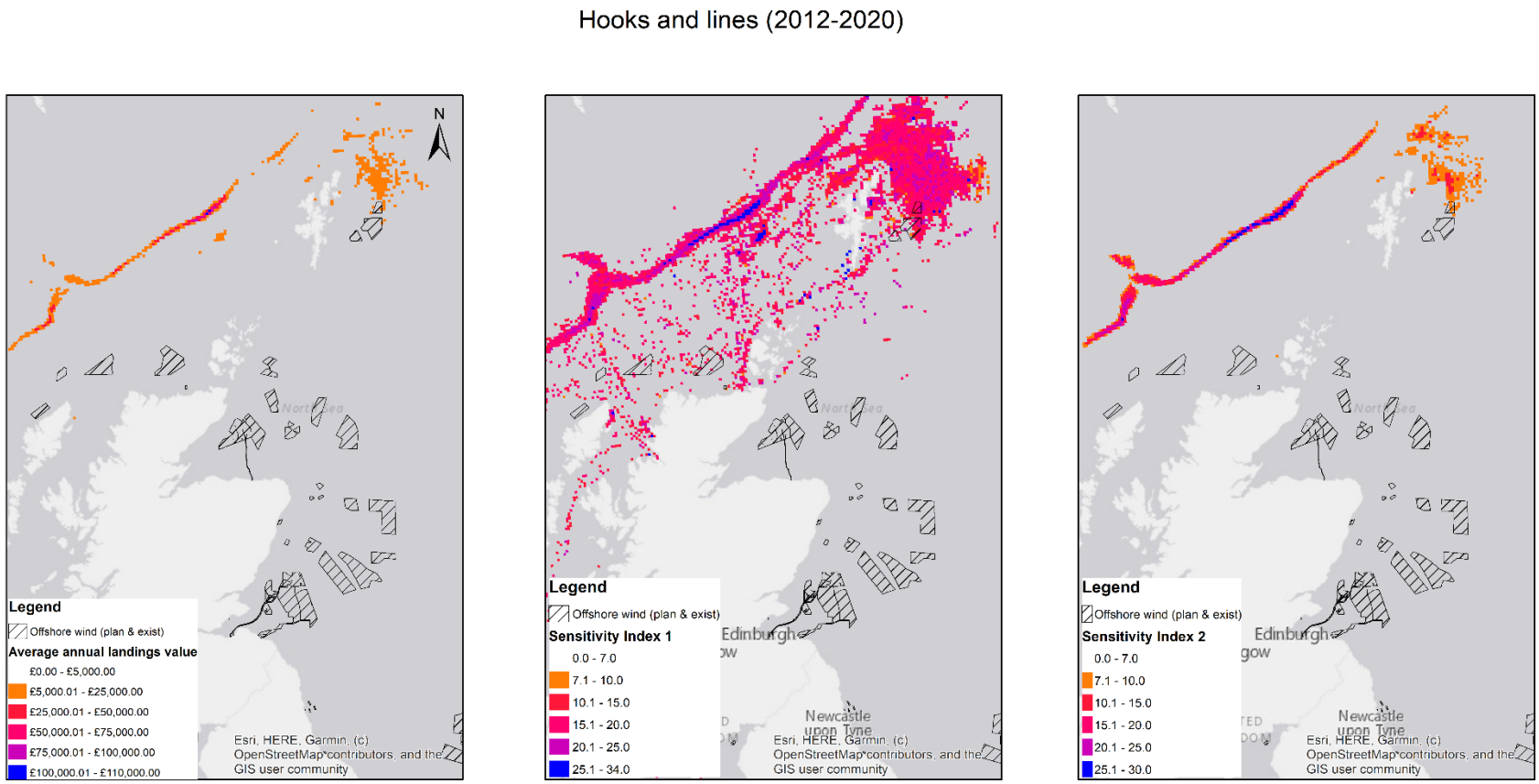

Figure 31: Sensitivity index 1 (9-years average) and index 2 (9-years average) in comparison to average annual landing values (2012-2020)

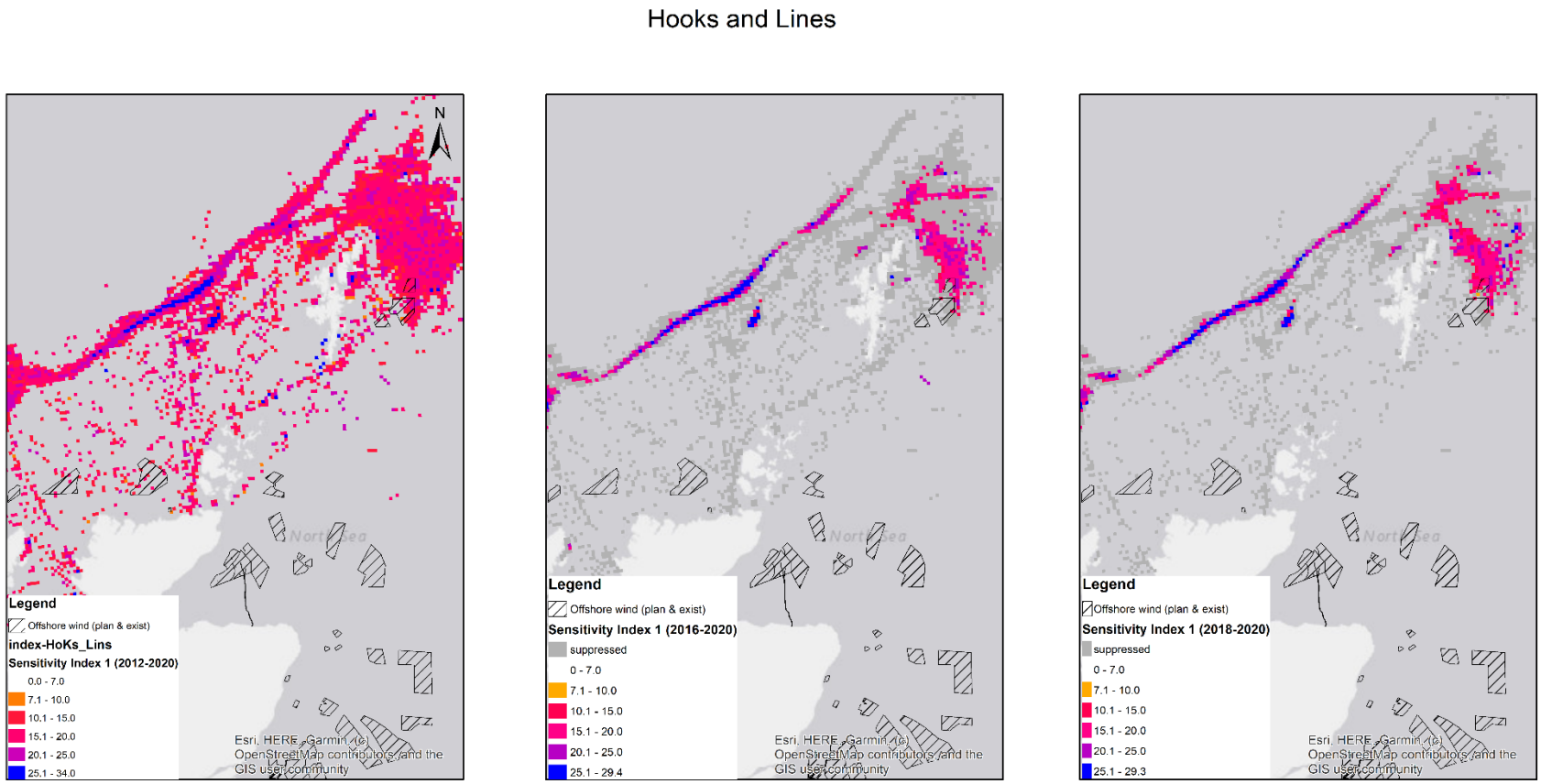

Figure 32: Sensitivity index 1 as 9-year average, 5-year average and 3-year average

Hooks and lines

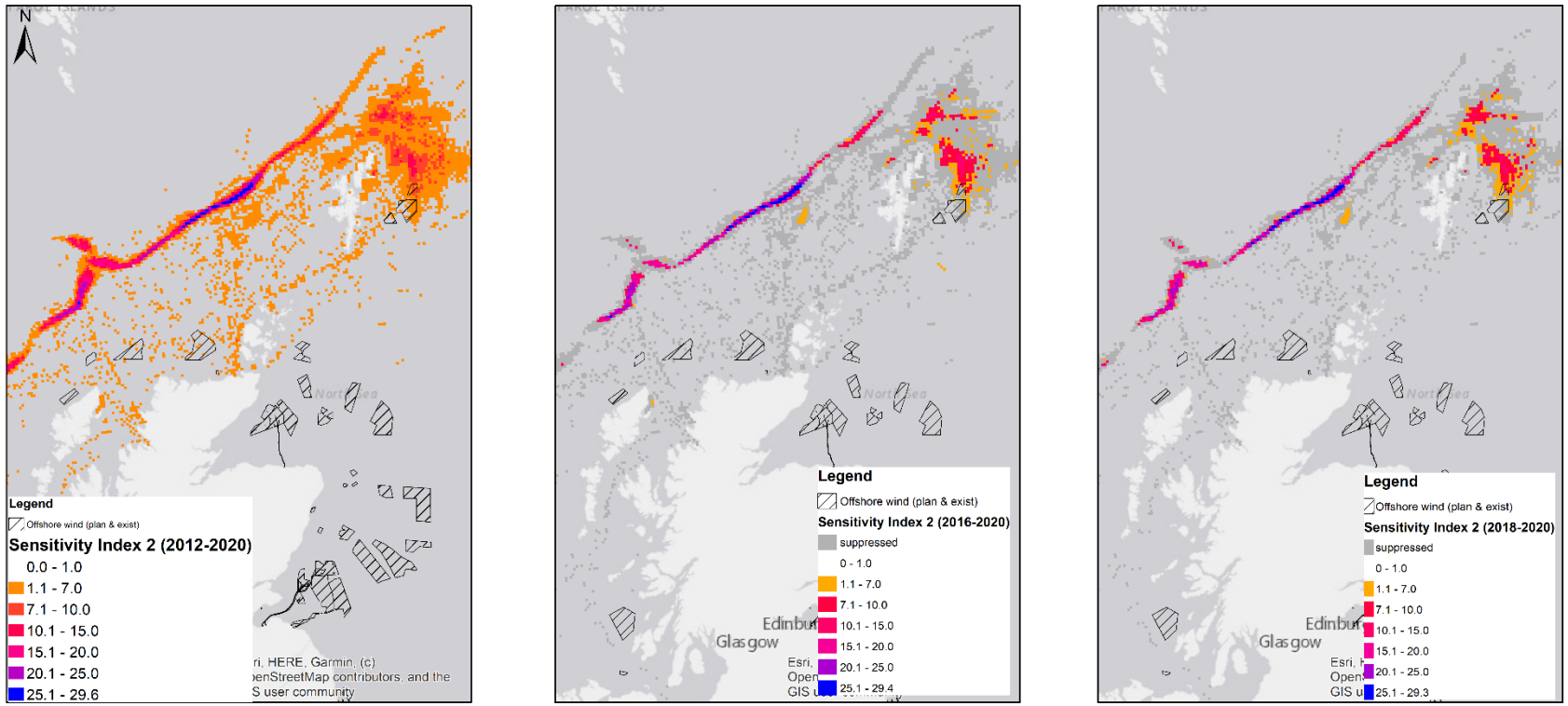

Figure 33: Sensitivity index 2 as 9-year average, 5-year average and 3-year average

Hooks and lines

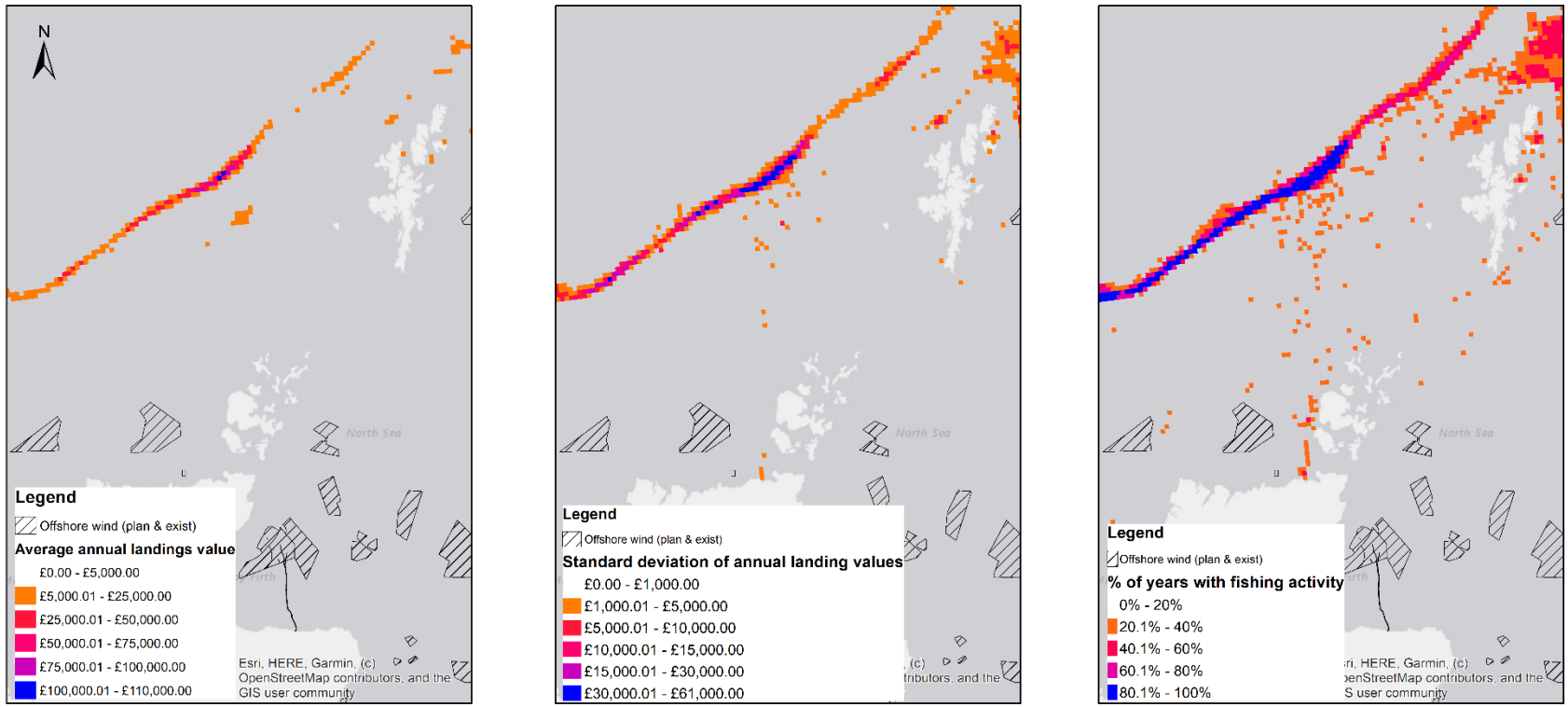

Figure 34 Example maps of Indicator 5a (Standard deviation of annual landing values) and Indicator 5b (Percentage of years the location was fished out of the 9 years here included) in comparison to long-term average annual landing values (2012-2020) for vessels using hooks and lines.

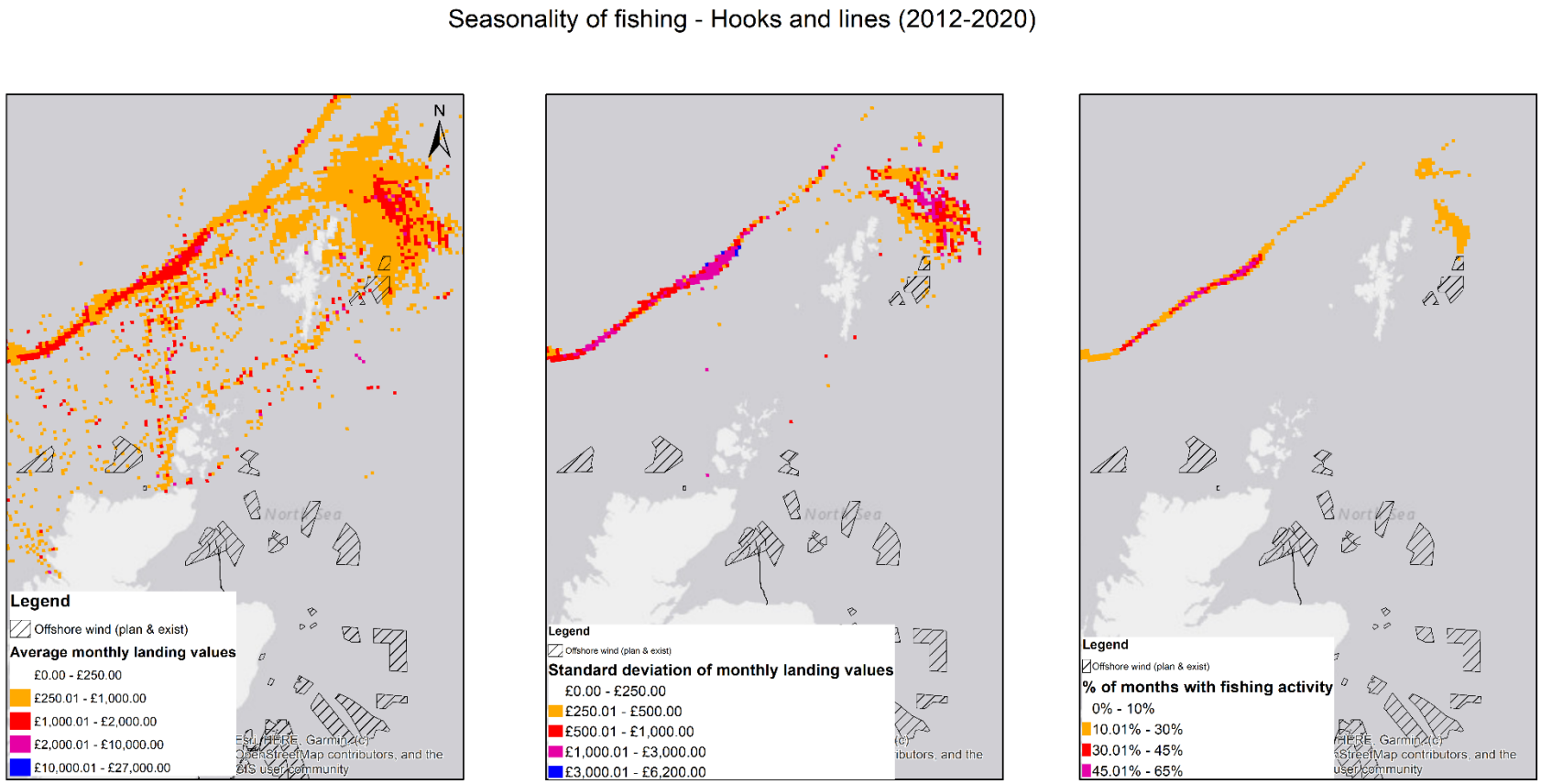

Figure 35: Example maps of Indicator 6a (Standard deviation of monthly landing values) and Indicator 6b (Percentage of months the location was fished out of the 9 years here included) in comparison to long-term average monthly landing values (2012-2020) for vessels using hooks and lines.

UK-flagged vessels using gear classified as Seine within the UK EEZ

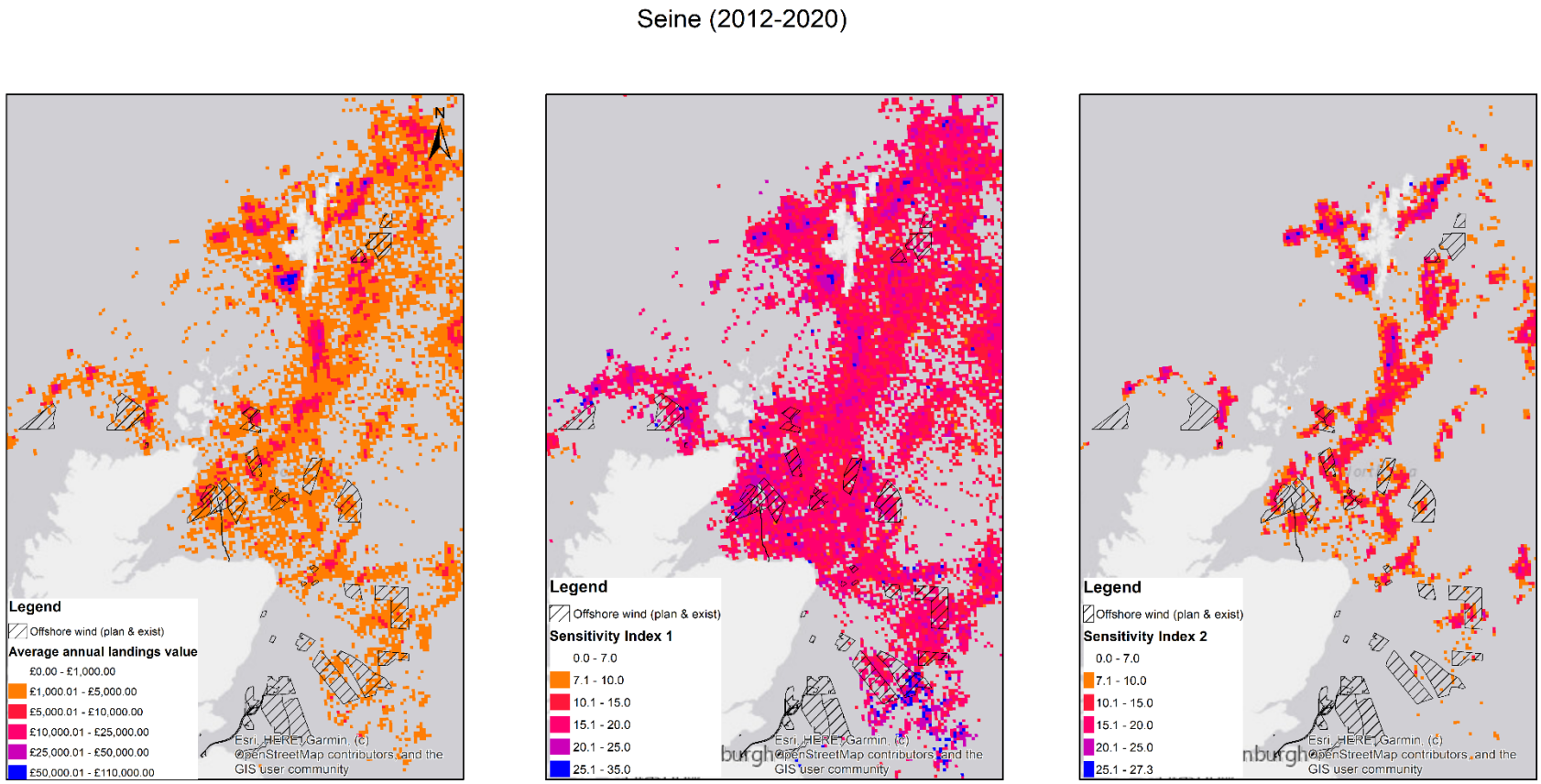

Figure 36: Sensitivity index 1 (9-years average) and index 2 (9-years average) in comparison to average annual landing values (2012-2020)

Seine

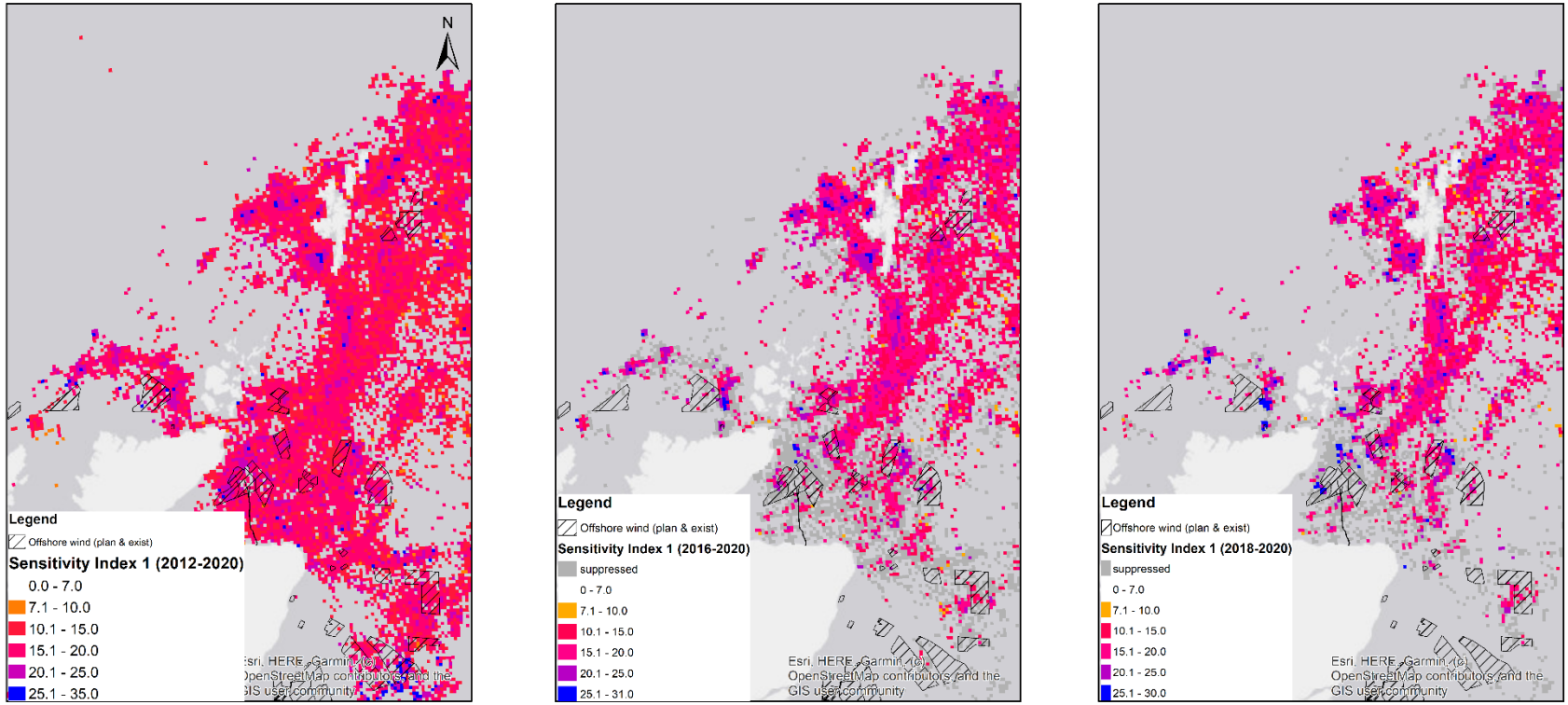

Figure 37: Sensitivity index 1 as 9-year average, 5-year average and 3-year average

Seine

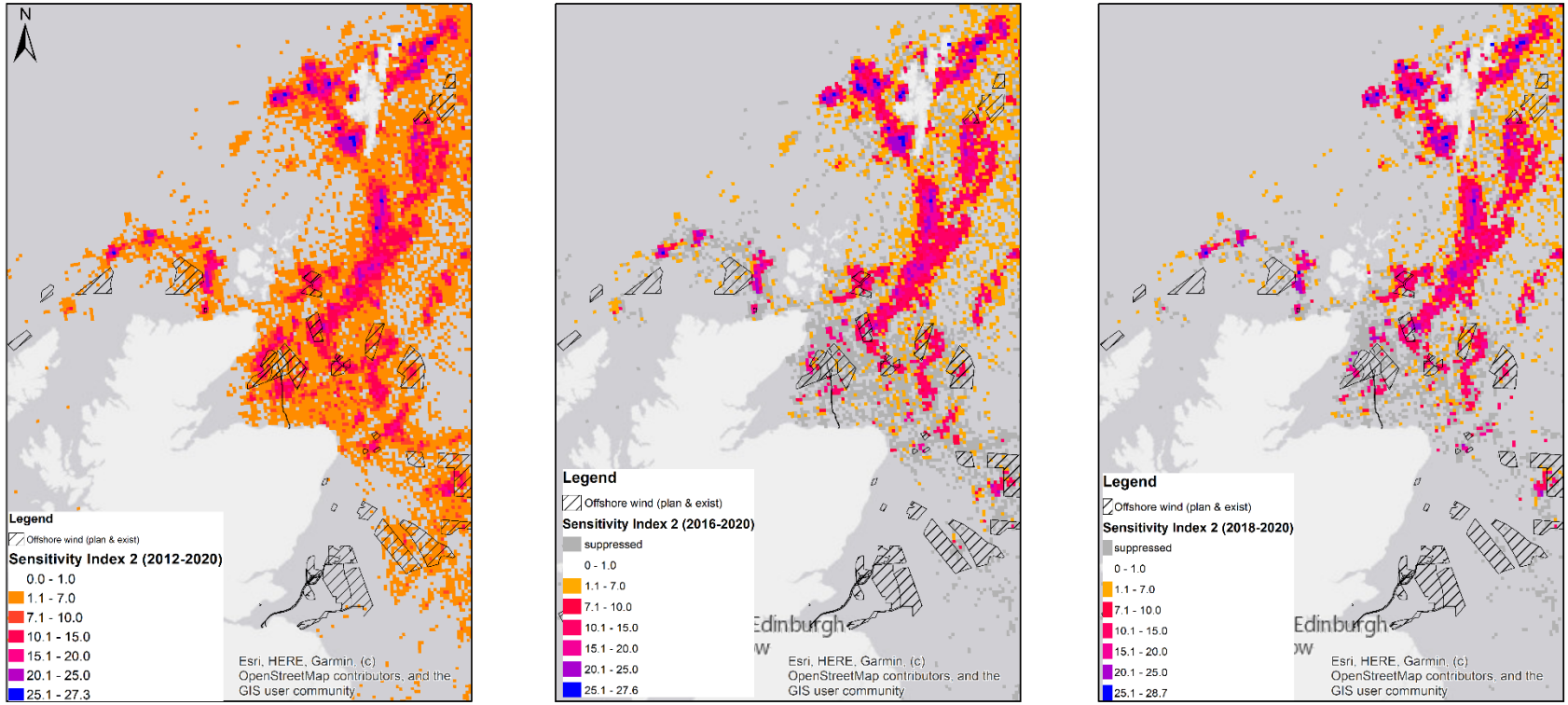

Figure 38: Sensitivity index 2 as 9-year average, 5-year average and 3-year average

Seine

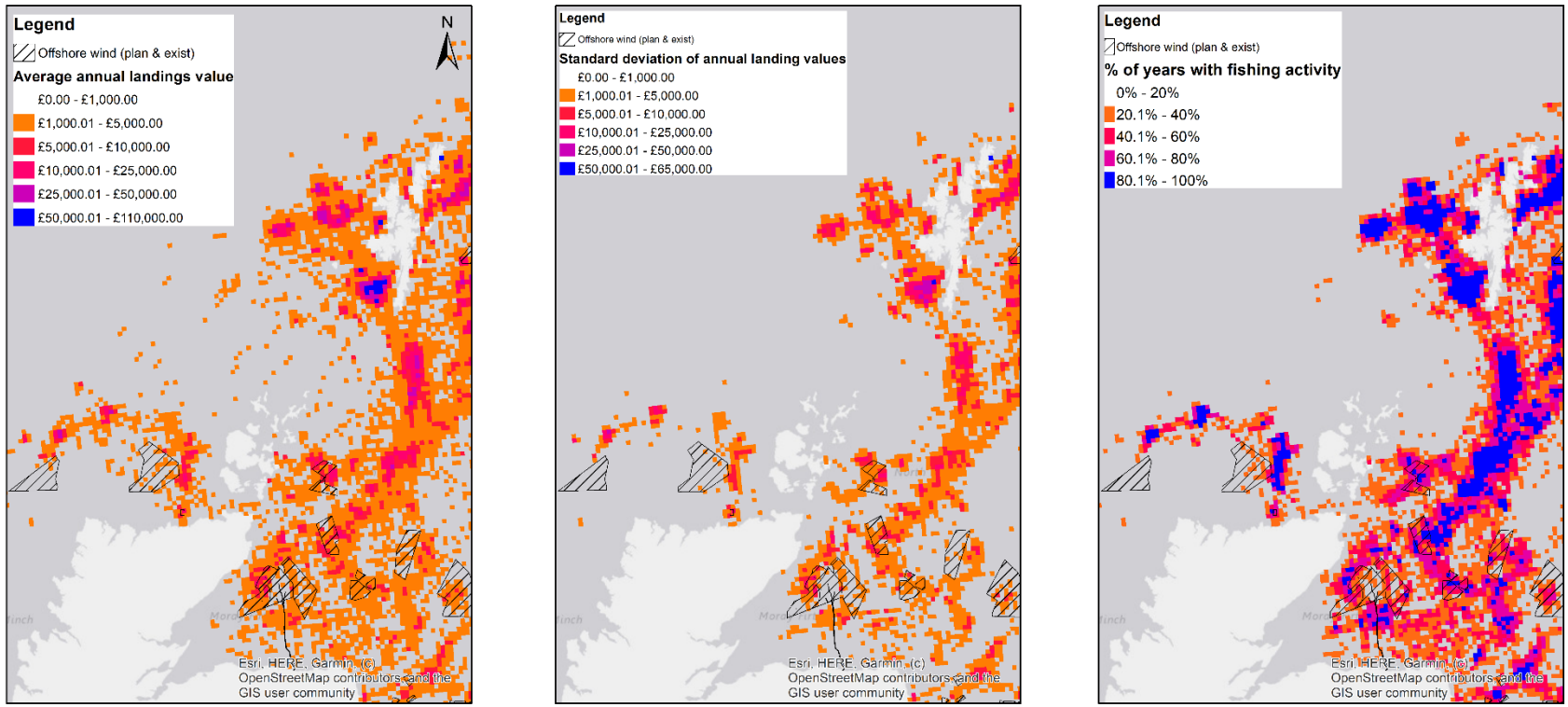

Figure 39: Example maps of Indicator 5a (Standard deviation of annual landing values) and Indicator 5b (Percentage of years the location was fished out of the 9 years here included) in comparison to long-term average annual landing values (2012-2020) for vessels using seine gear.

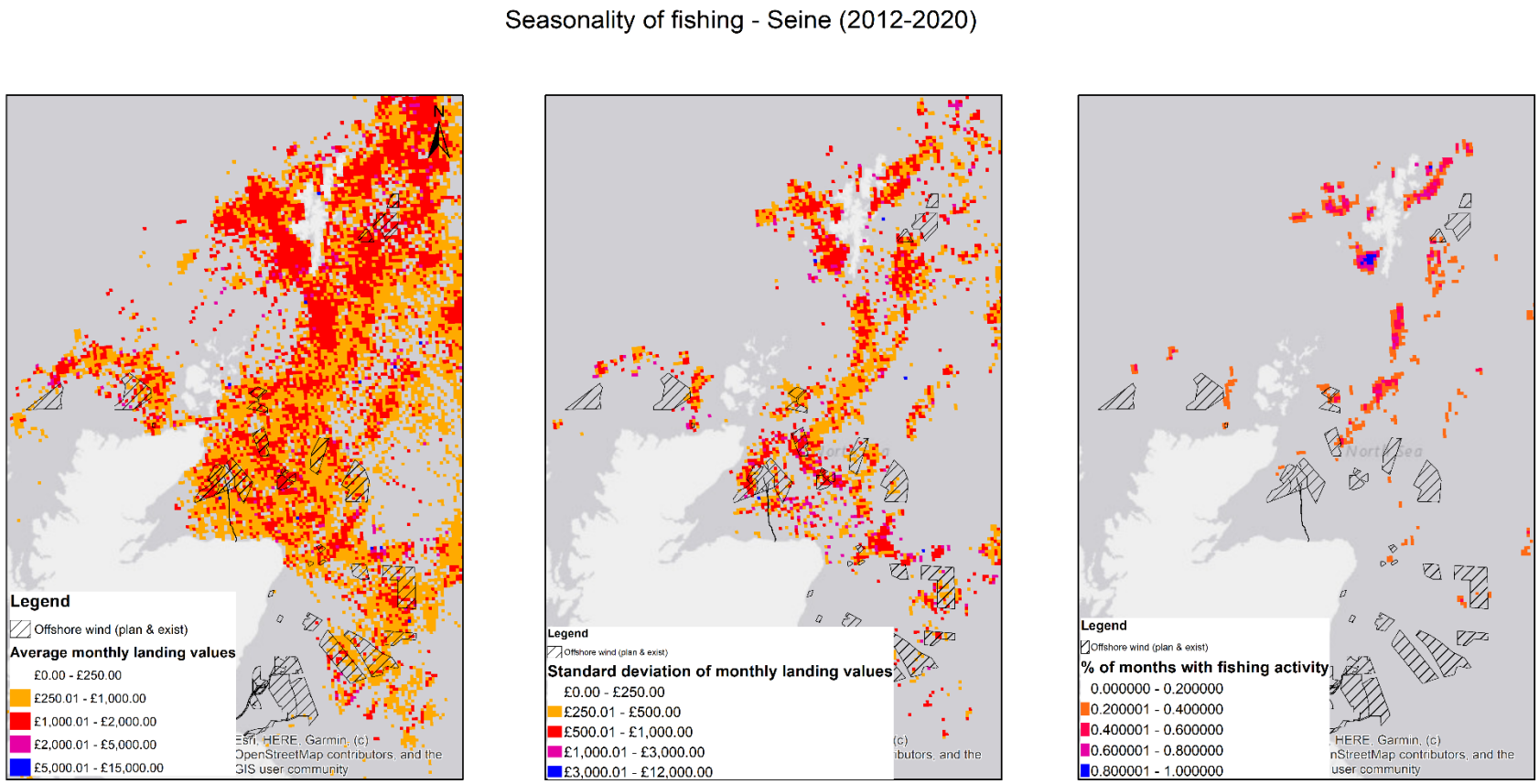

Figure 40: Example maps of Indicator 6a (Standard deviation of monthly landing values) and Indicator 6b (Percentage of months the location was fished out of the 9 years here included) in comparison to long-term average annual landing values (2012-2020) for vessel using seine.

UK-flagged vessels using gear classified as Surrounding gears within the UK EEZ

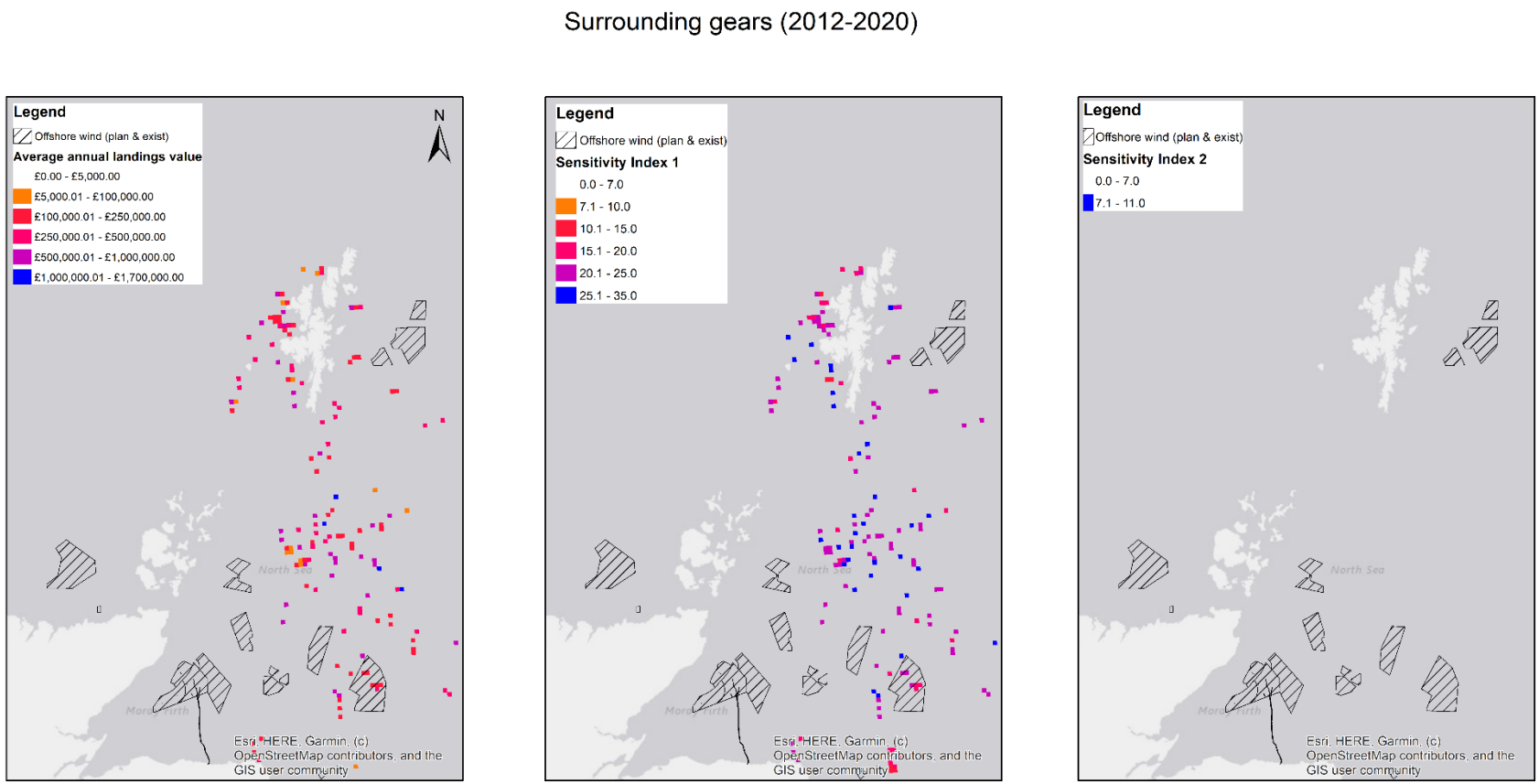

Figure 41: Sensitivity index 1 (9-years average) and index 2 (9-years average) in comparison to average annual landing values (2012-2020)

Surrounding gears

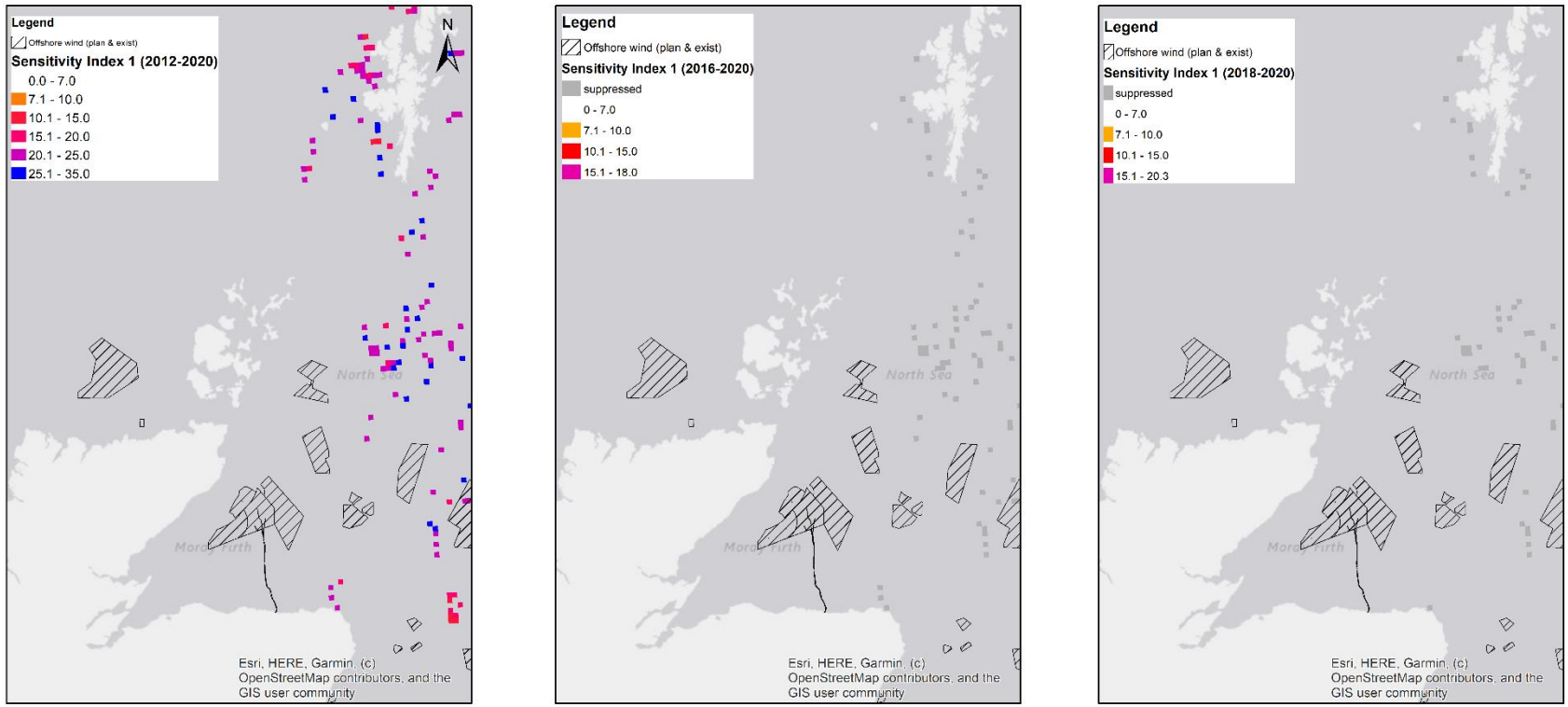

Figure 42: Sensitivity index 1 as 9-year average, 5-year average and 3-year average

Surrounding gears

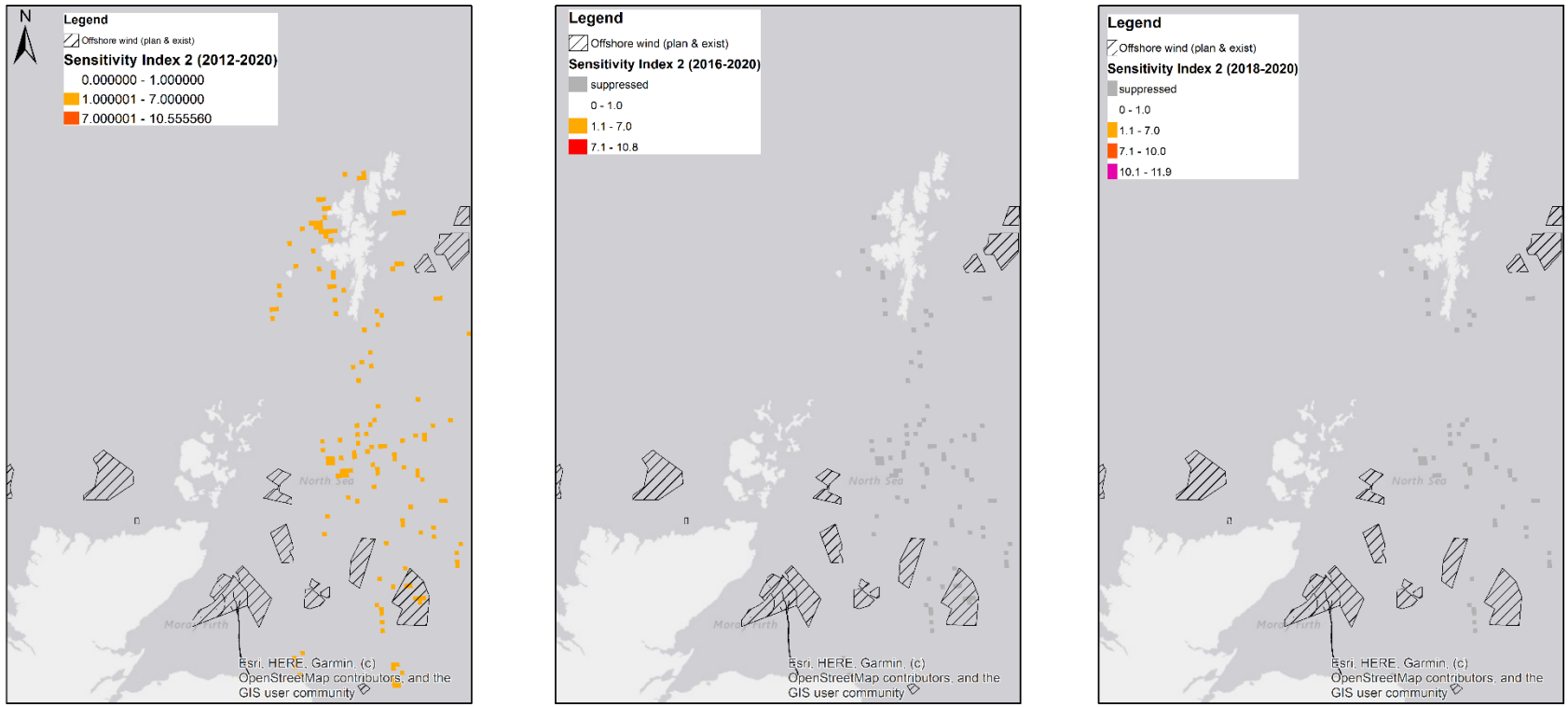

Figure 43: Sensitivity index 2 as 9-year average, 5-year average and 3-year average

Surounding gears

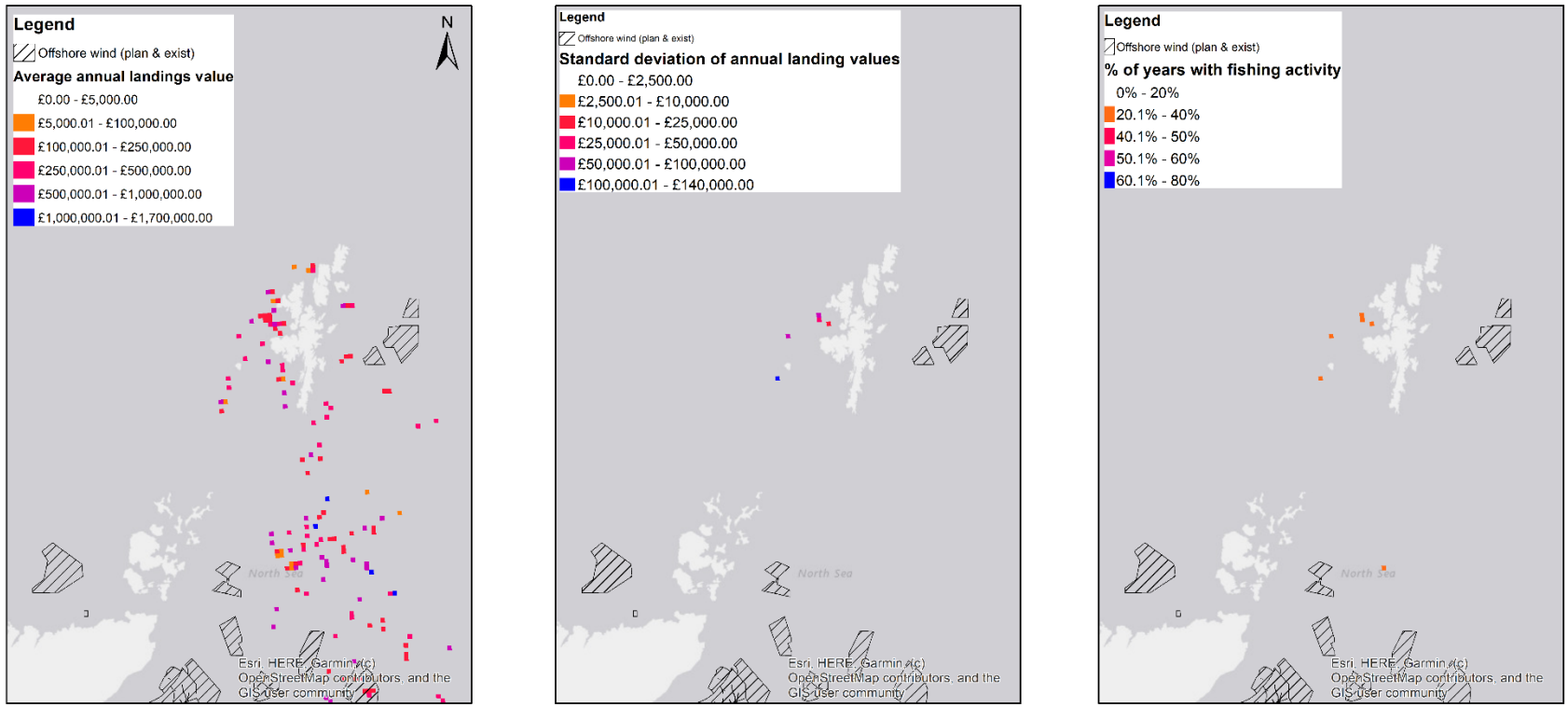

Figure 44: Example maps of Indicator 5a (Standard deviation of annual landing values) and Indicator 5b (Percentage of years the location was fished out of the 9 years here included) in comparison to long-term average annual landing values (2012-2020) for vessels using surrounding gears.

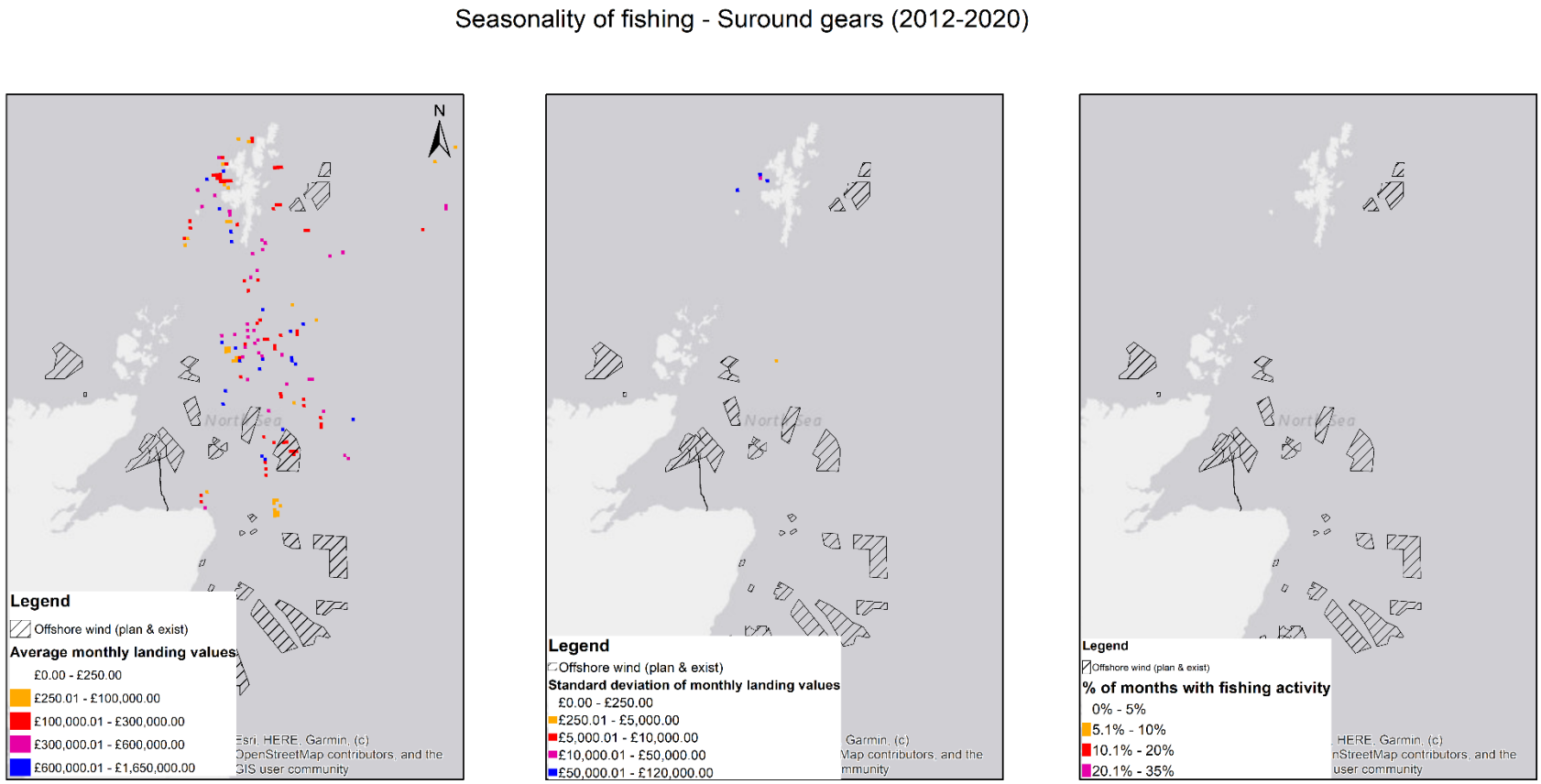

Figure 45: Example maps of Indicator 6a (Standard deviation of monthly landing values) and Indicator 6b (Percentage of months the location was fished out of the 9 years here included) in comparison to long-term average annual landing values (2012-2020) for vessel using surrounding gears.

UK-flagged vessels using gear classified as pots and traps within the UK EEZ

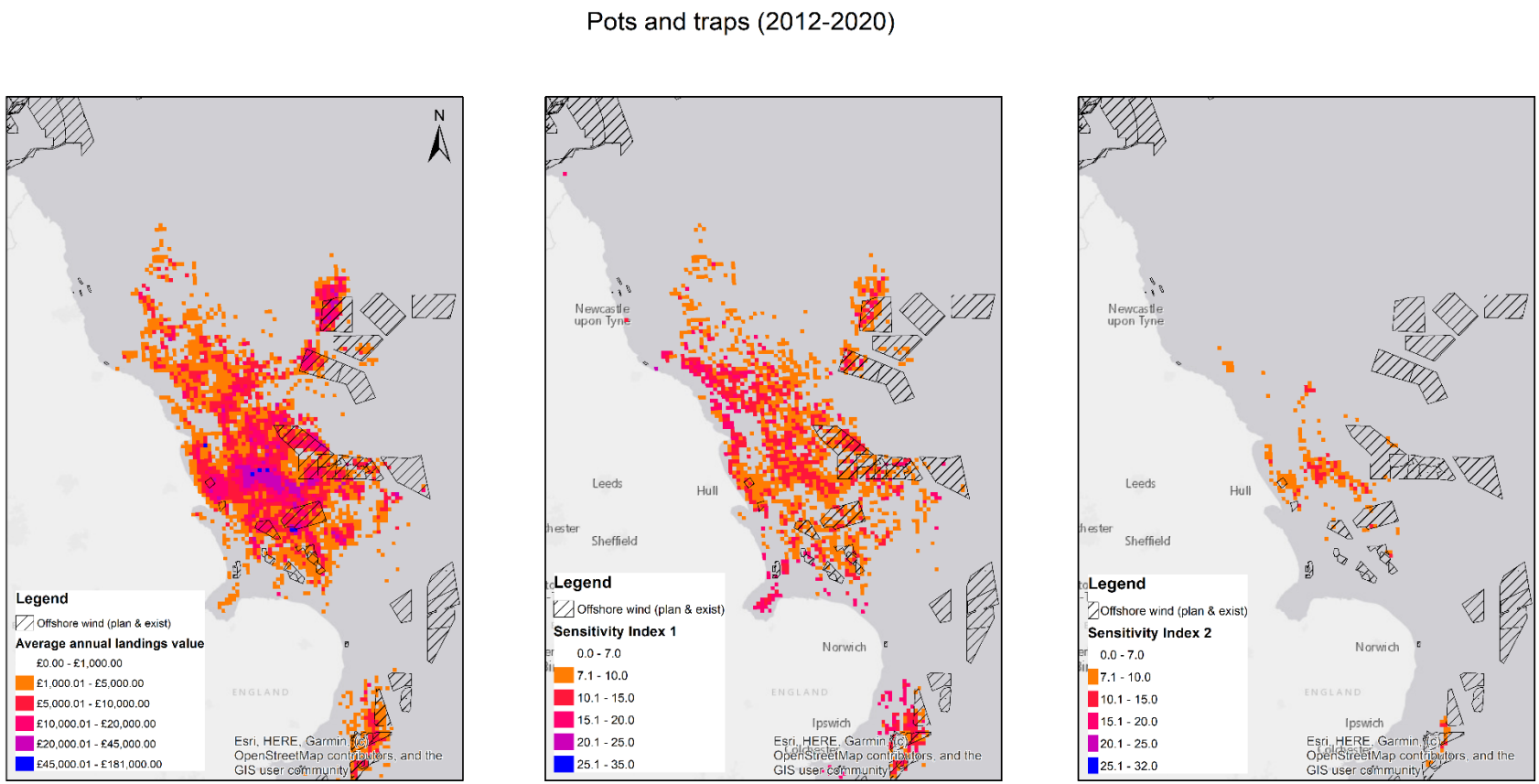

Figure 46: Sensitivity index 1 (9-years average) and index 2 (9-years average) in comparison to average annual landing values (2012-2020)

Pots and traps

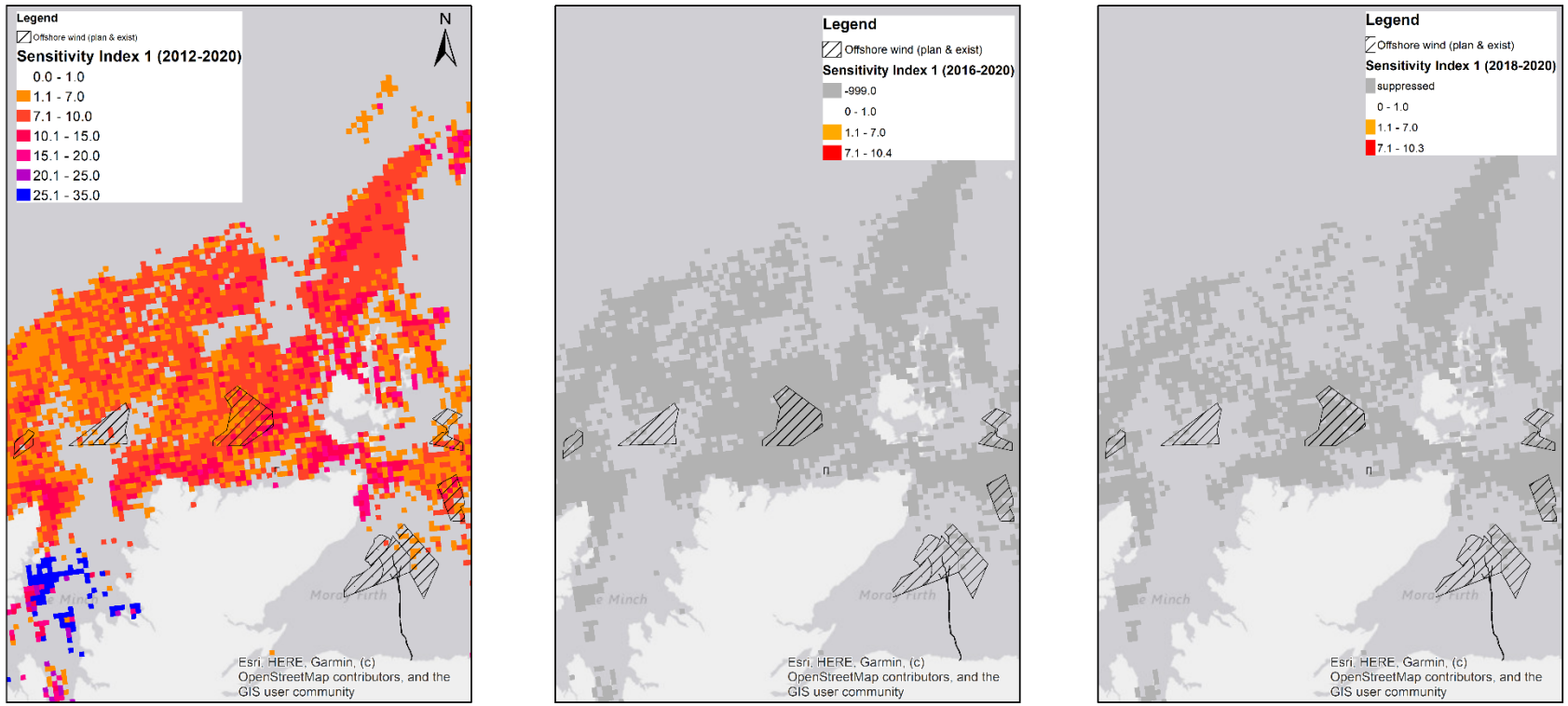

Figure 47: Sensitivity index 1 as 9-year average, 5-year average and 3-year average

Pots and traps

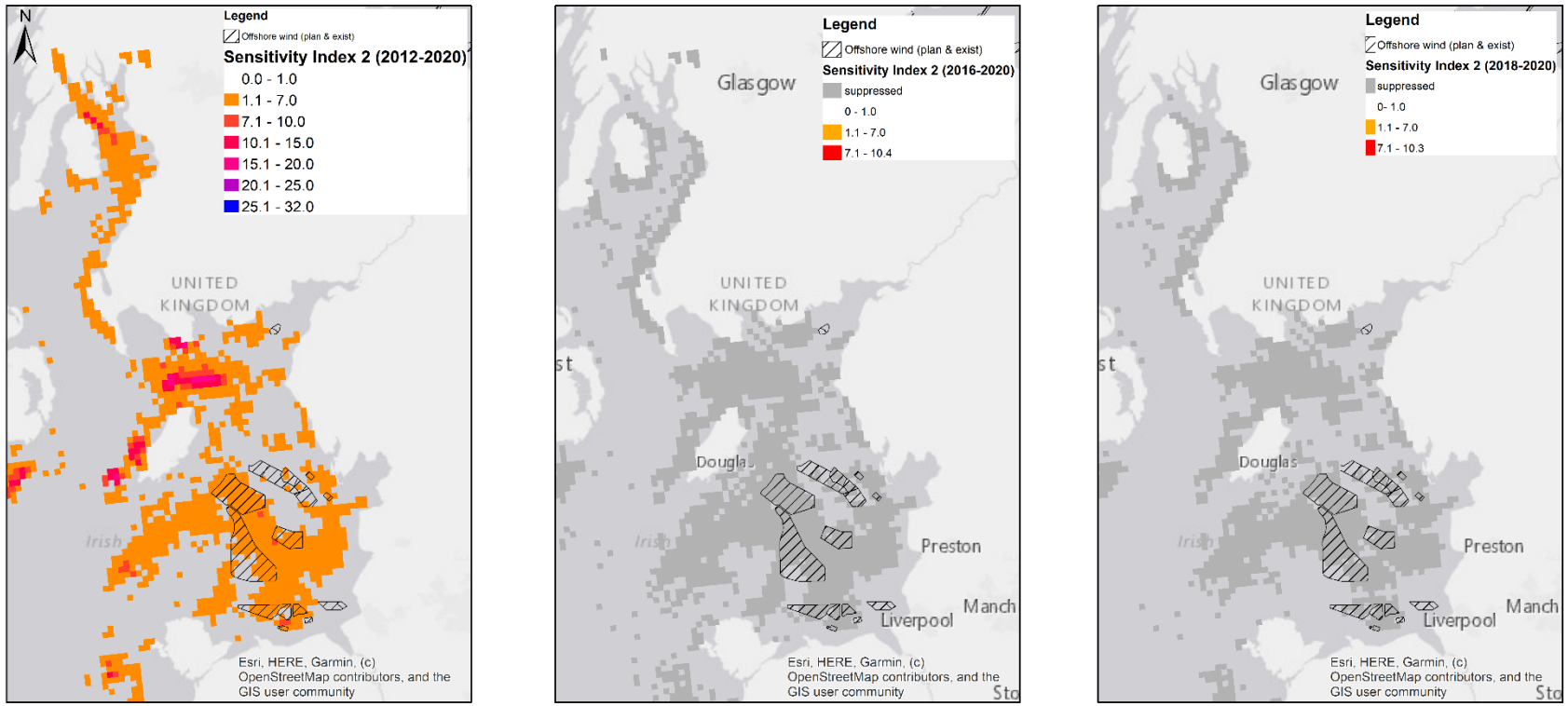

Figure 48: Sensitivity index 2 as 9-year average, 5-year average and 3-year average

Pots and traps

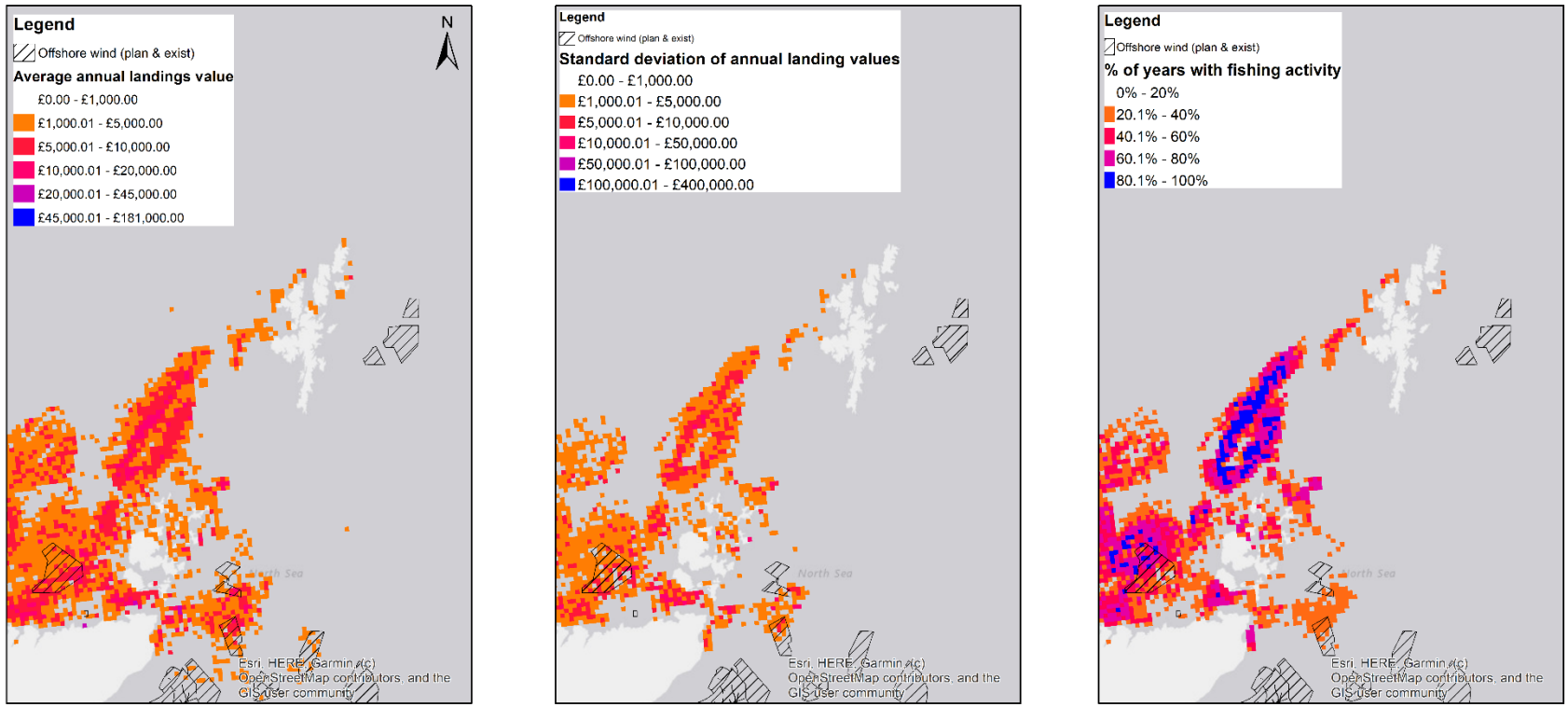

Figure 49: Example maps of Indicator 5a (Standard deviation of annual landing values) and Indicator 5b (Percentage of years the location was fished out of the 9 years here included) in comparison to long-term average annual landing values (2012-2020) for vessels using pots and traps.

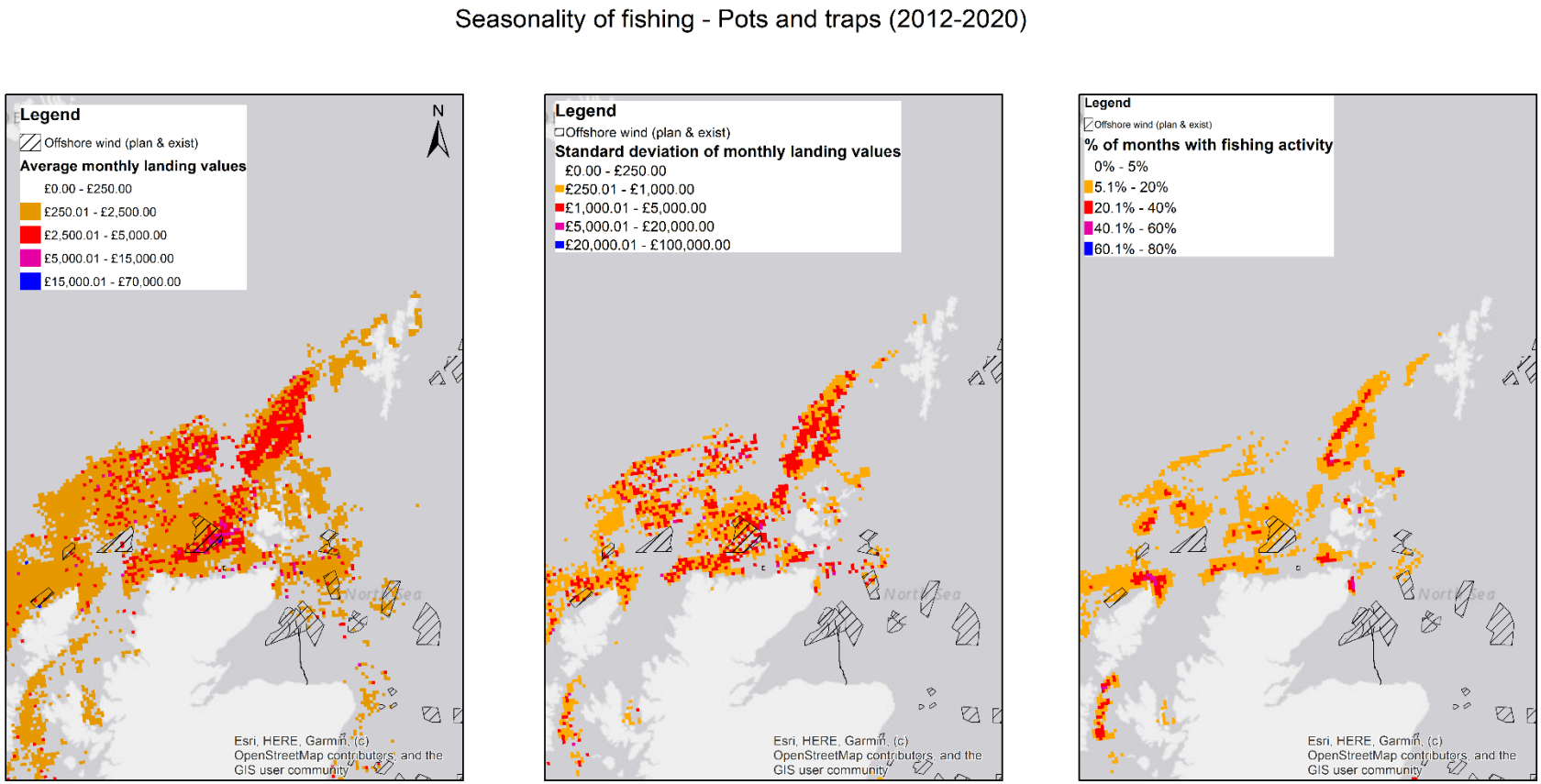

Figure 50: Example maps of Indicator 6a (Standard deviation of monthly landing values) and Indicator 6b (Percentage of months the location was fished out of the 9 years here included) in comparison to long-term average annual landing values (2012-2020) for vessel using pots and traps.

UK-flagged vessels using gear classified as dredges within the UK EEZ

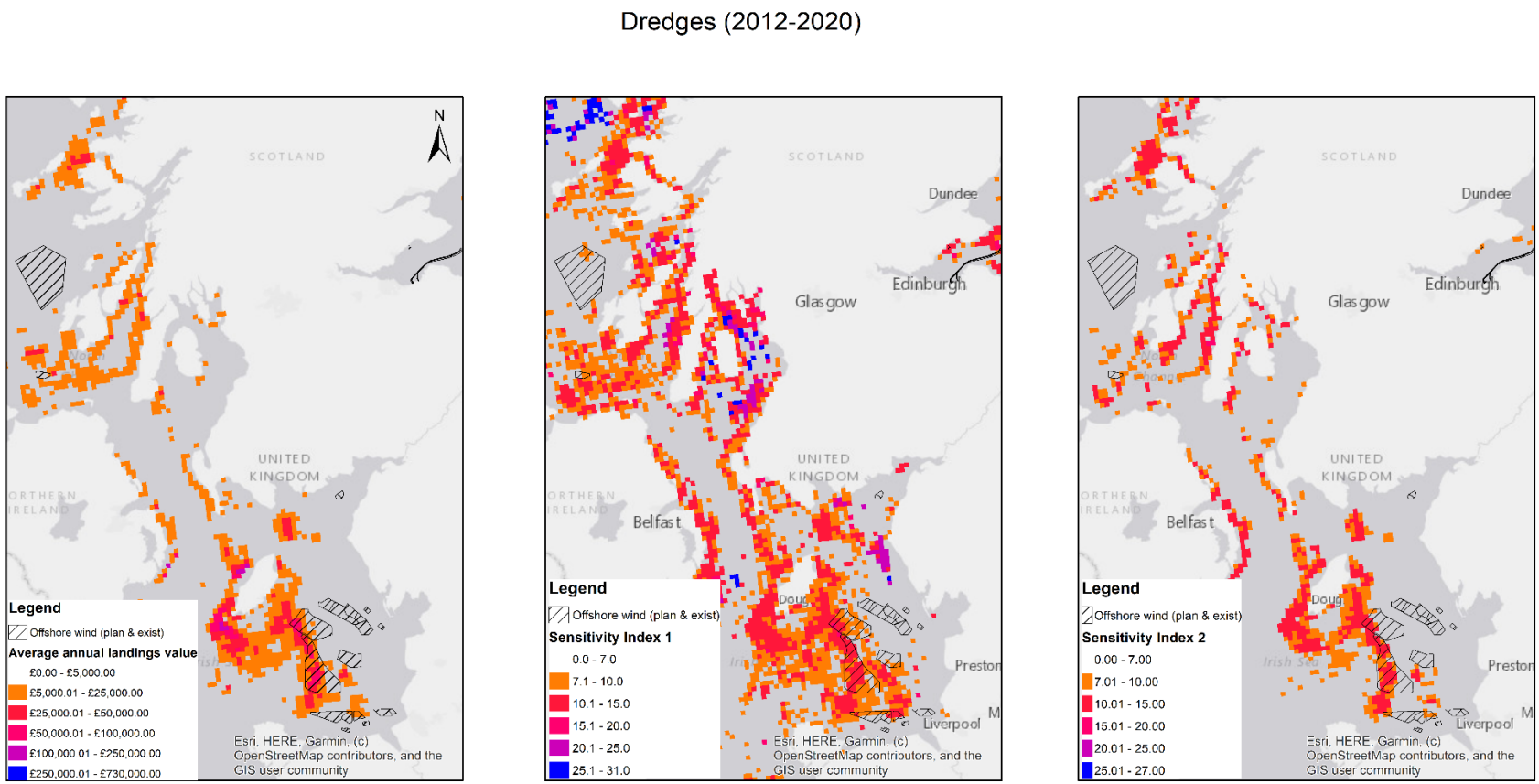

Figure 51: Sensitivity index 1 (9-years average) and index 2 (9-years average) in comparison to average annual landing values (2012-2020)

Dredges

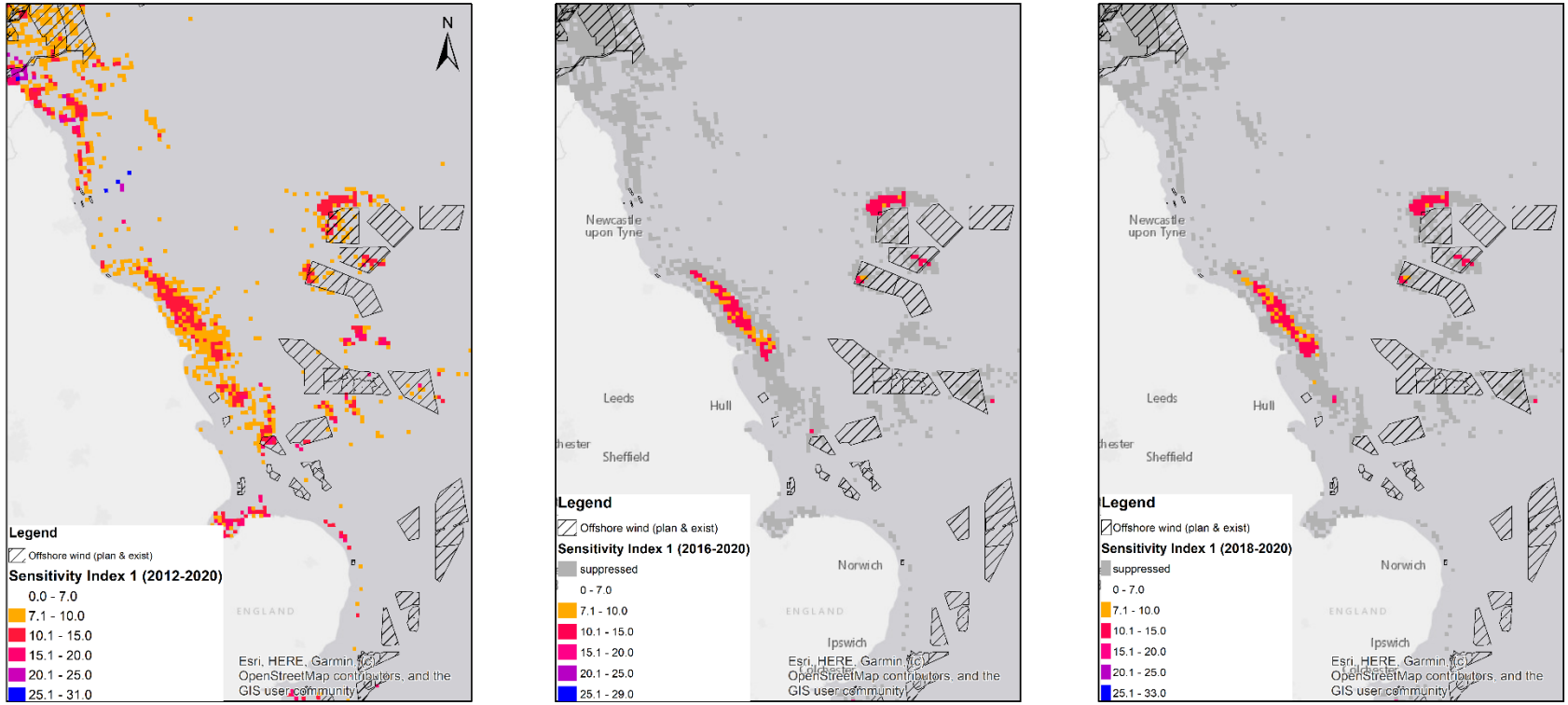

Figure 52: Sensitivity index 1 as 9-year average, 5-year average and 3-year average

Dredges

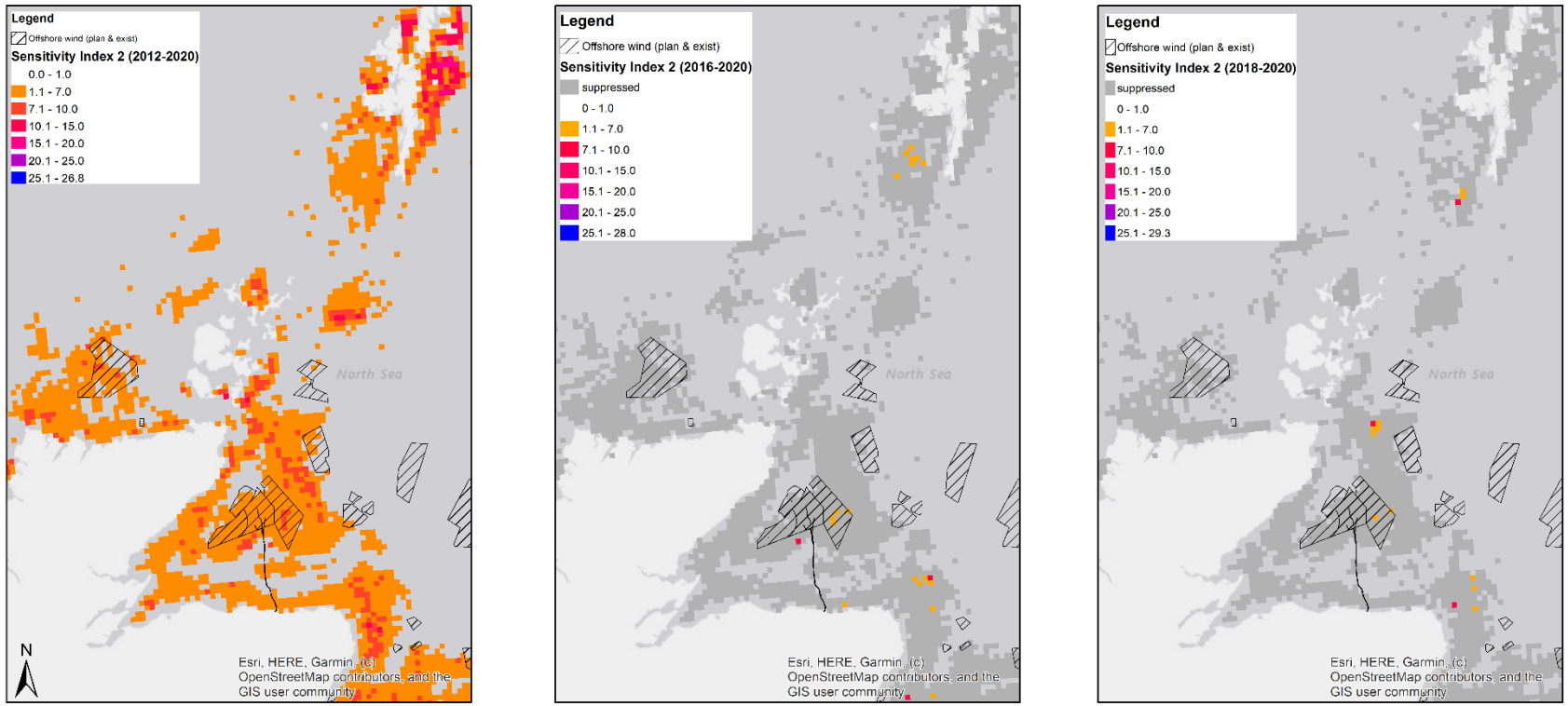

Figure 53: Sensitivity index 2 as 9-year average, 5-year average and 3-year average

Dredges

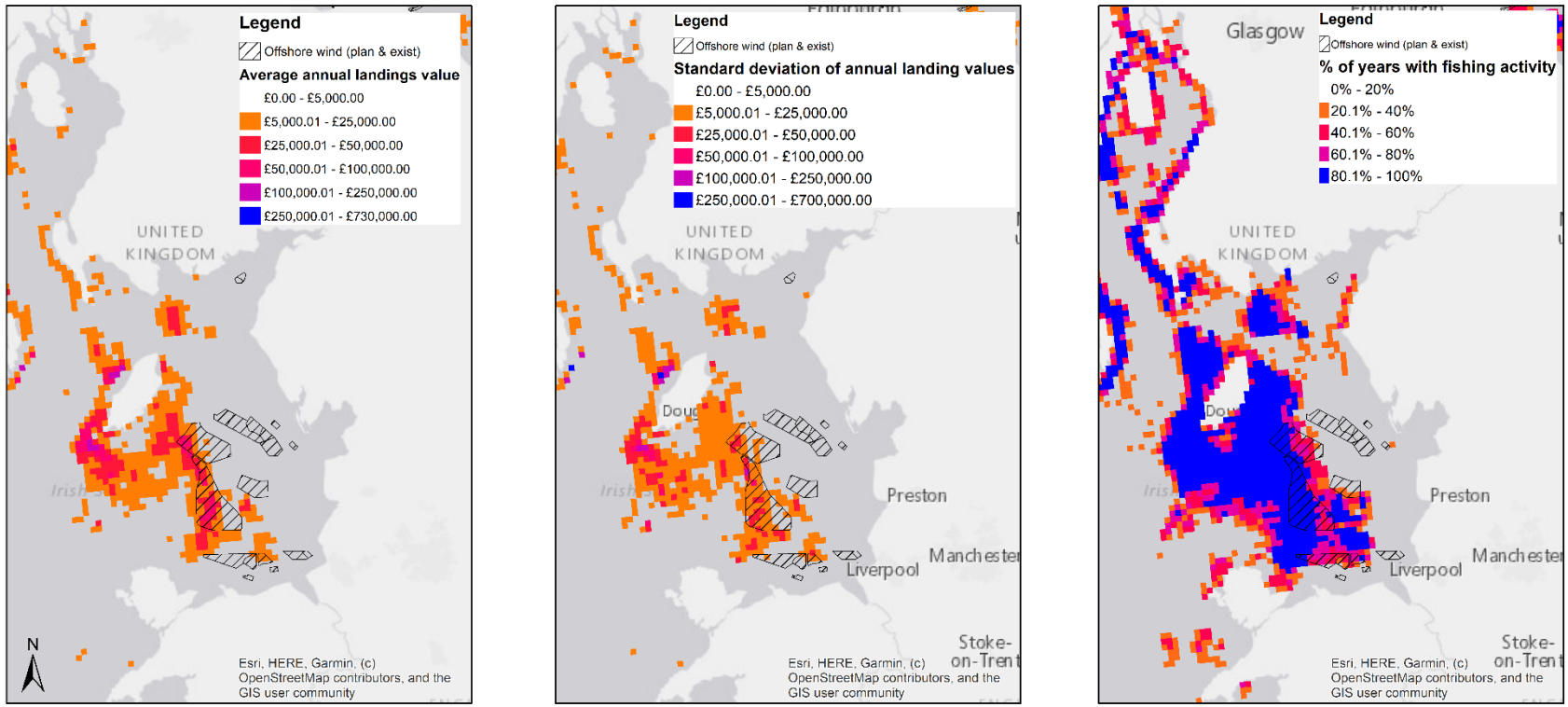

Figure 54: Example maps of Indicator 5a (Standard deviation of annual landing values) and Indicator 5b (Percentage of years the location was fished out of the 9 years here included) in comparison to long-term average annual landing values (2012-2020) for vessels using dredges.

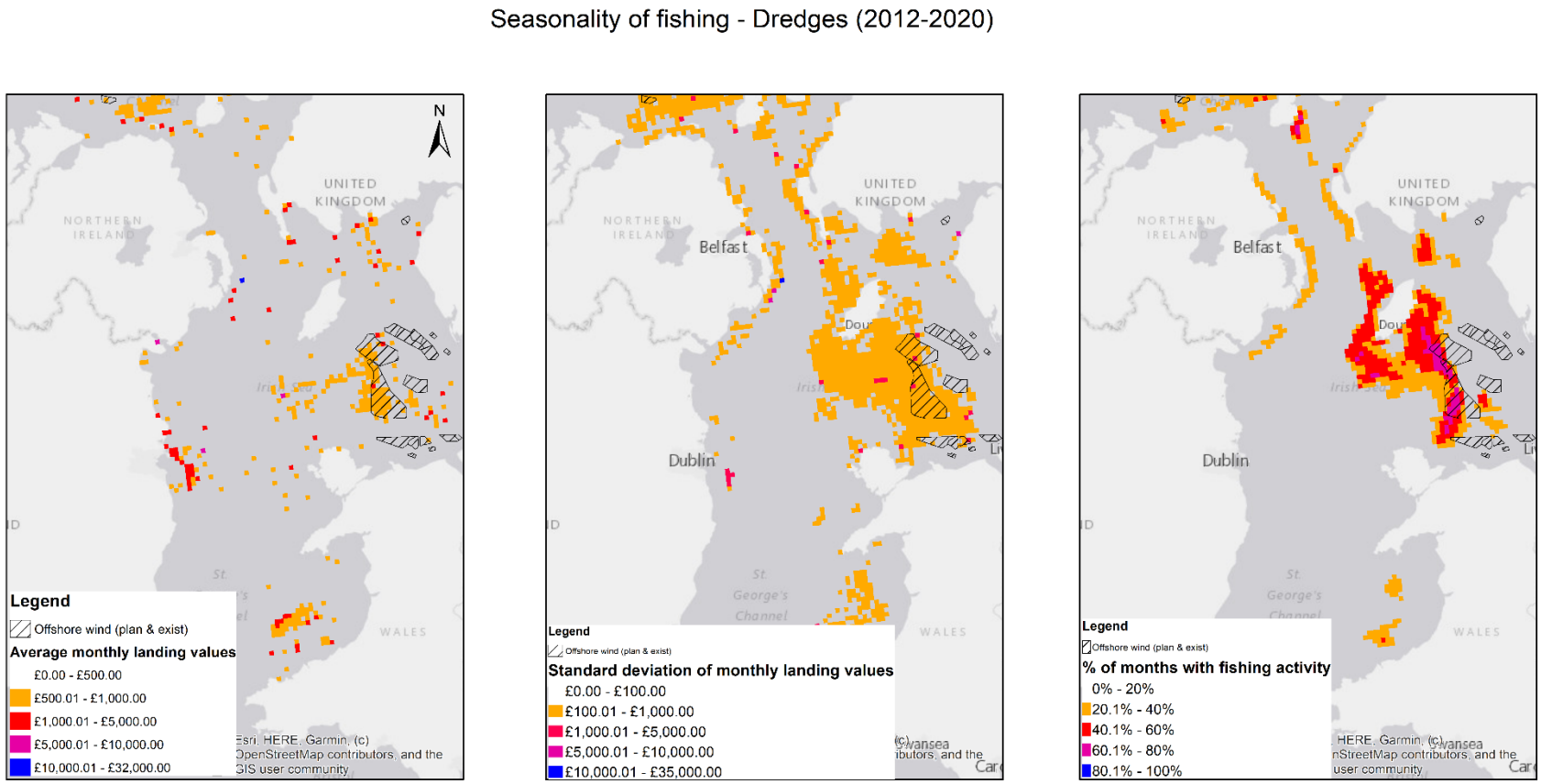

Figure 55: Example maps of Indicator 6a (Standard deviation of monthly landing values) and Indicator 6b (Percentage of months the location was fished out of the 9 years here included) in comparison to long-term average annual landing values (2012-2020) for vessel using dredges.

UK-flagged vessels using gear classified as gillnets or/and entangled nets within the UK EEZ

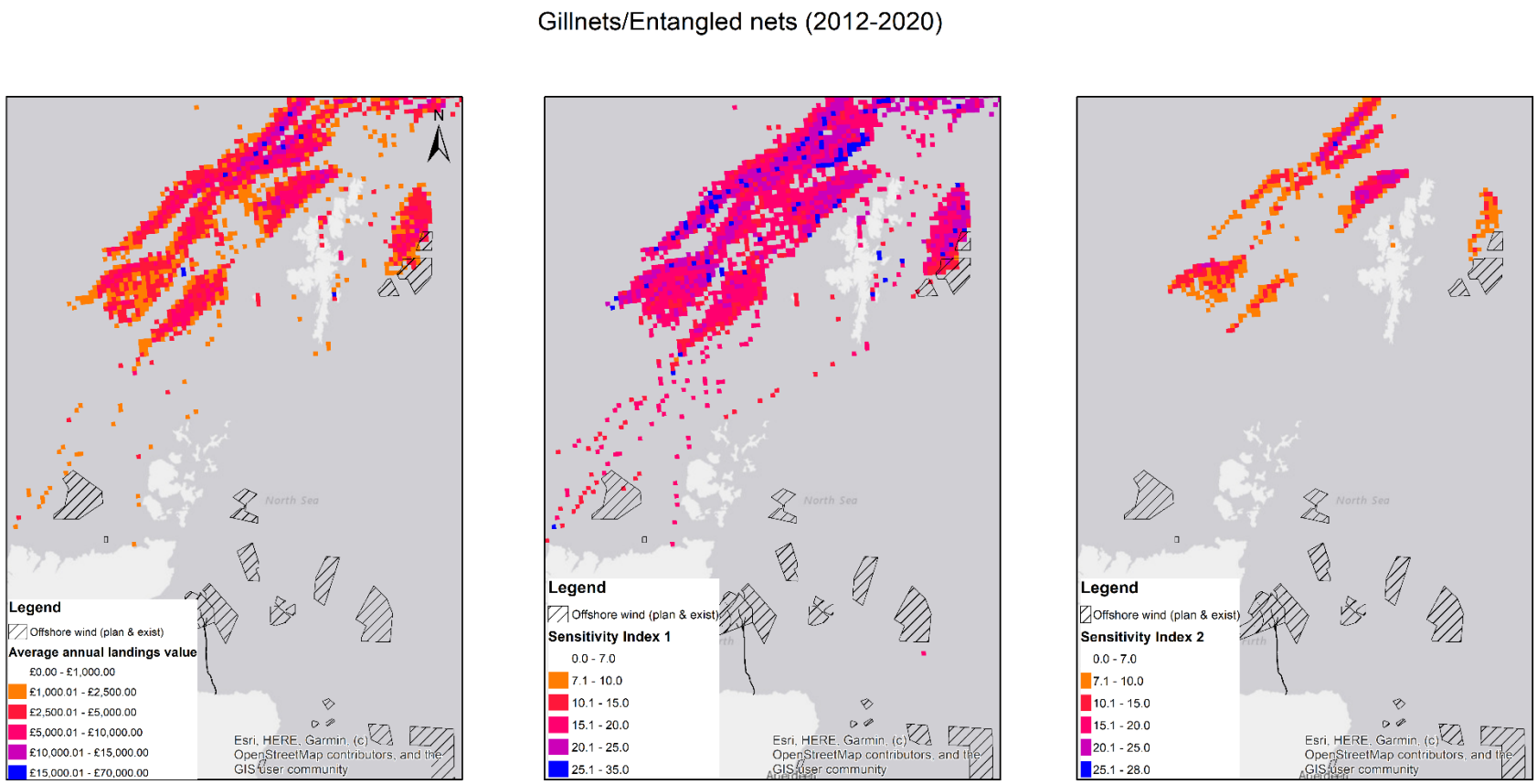

Figure 56: Sensitivity index 1 (9-years average) and index 2 (9-years average) in comparison to average annual landing values (2012-2020)

Gillnets/Entangled nets

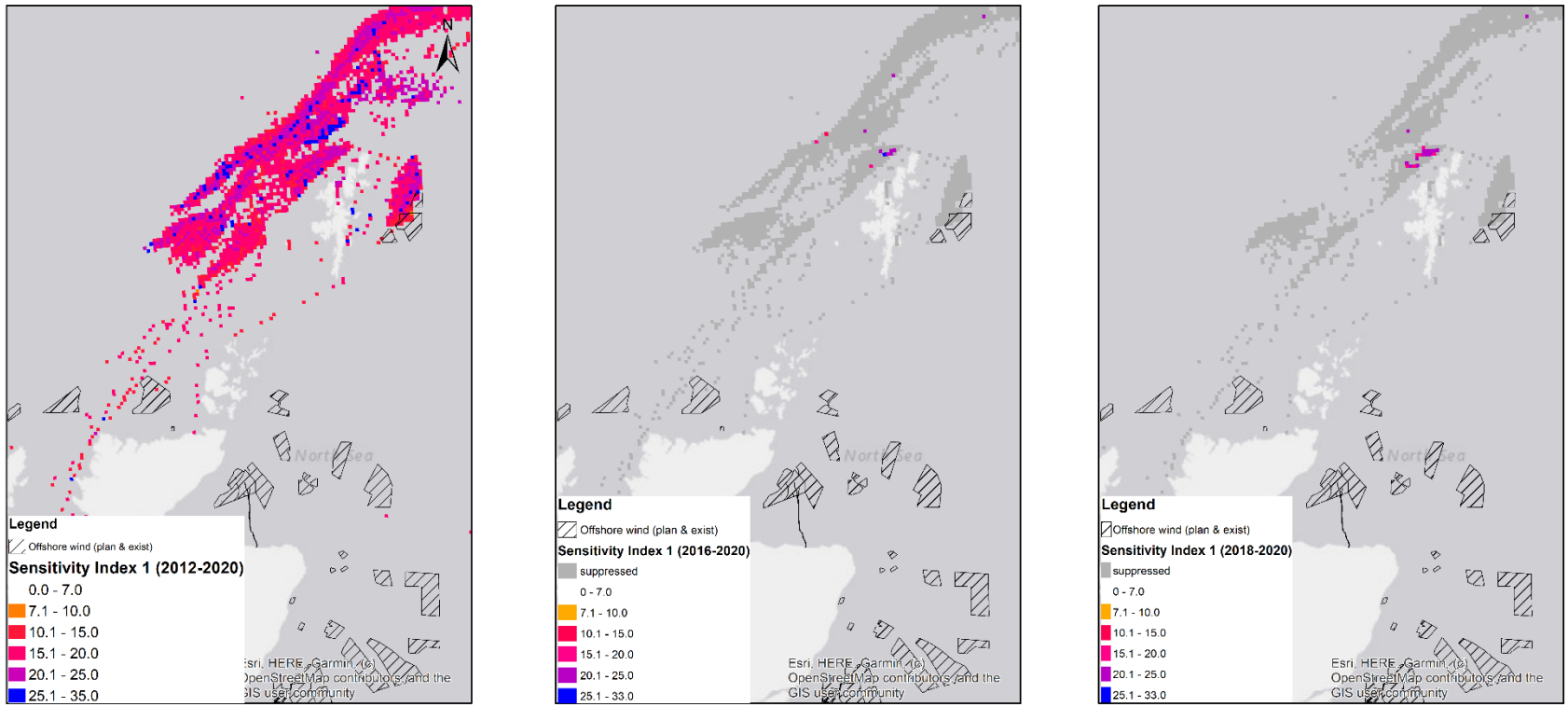

Figure 57: Sensitivity index 1 as 9-year average, 5-year average and 3-year average

Gillnets / Entangled nets

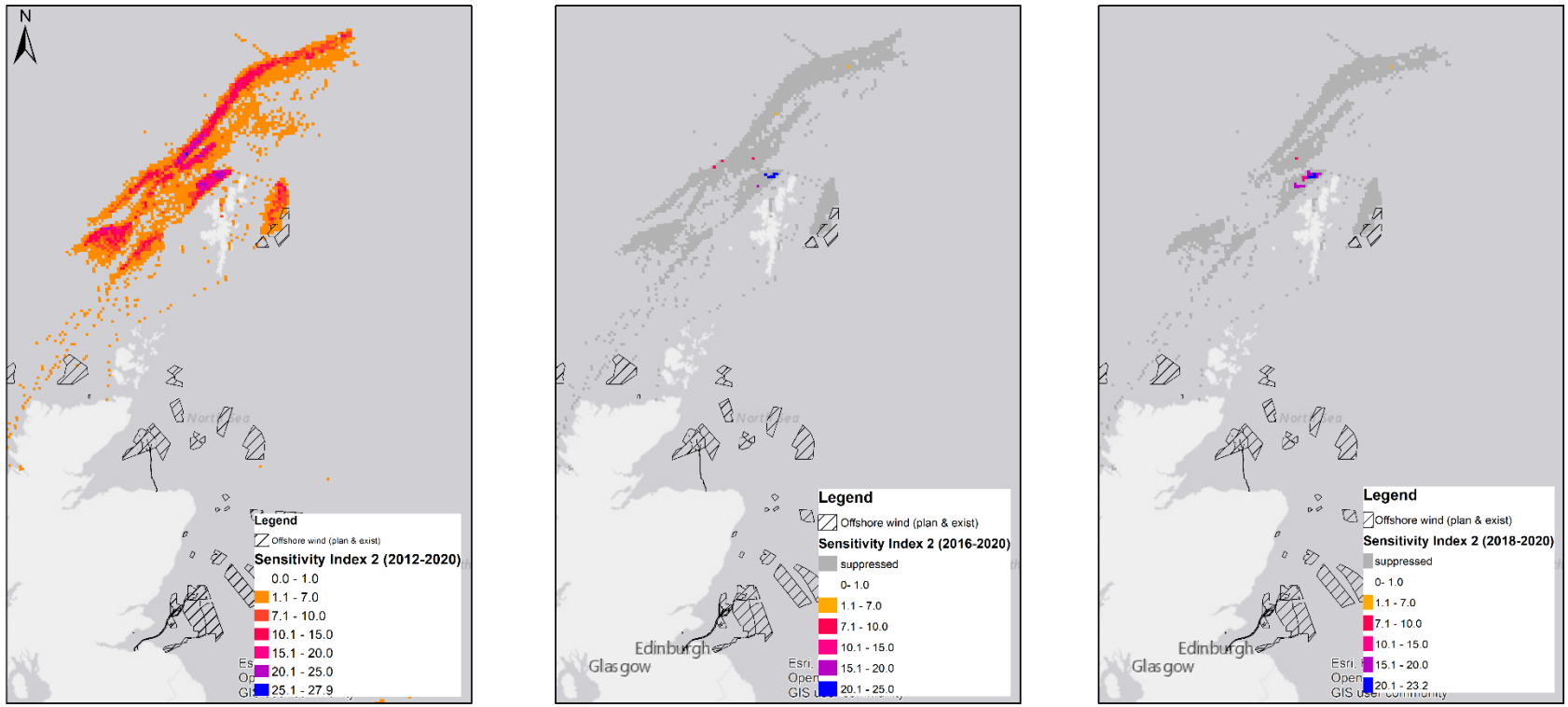

Figure 58: Sensitivity index 2 as 9-year average, 5-year average and 3-year average

Gillnet / Entangled net

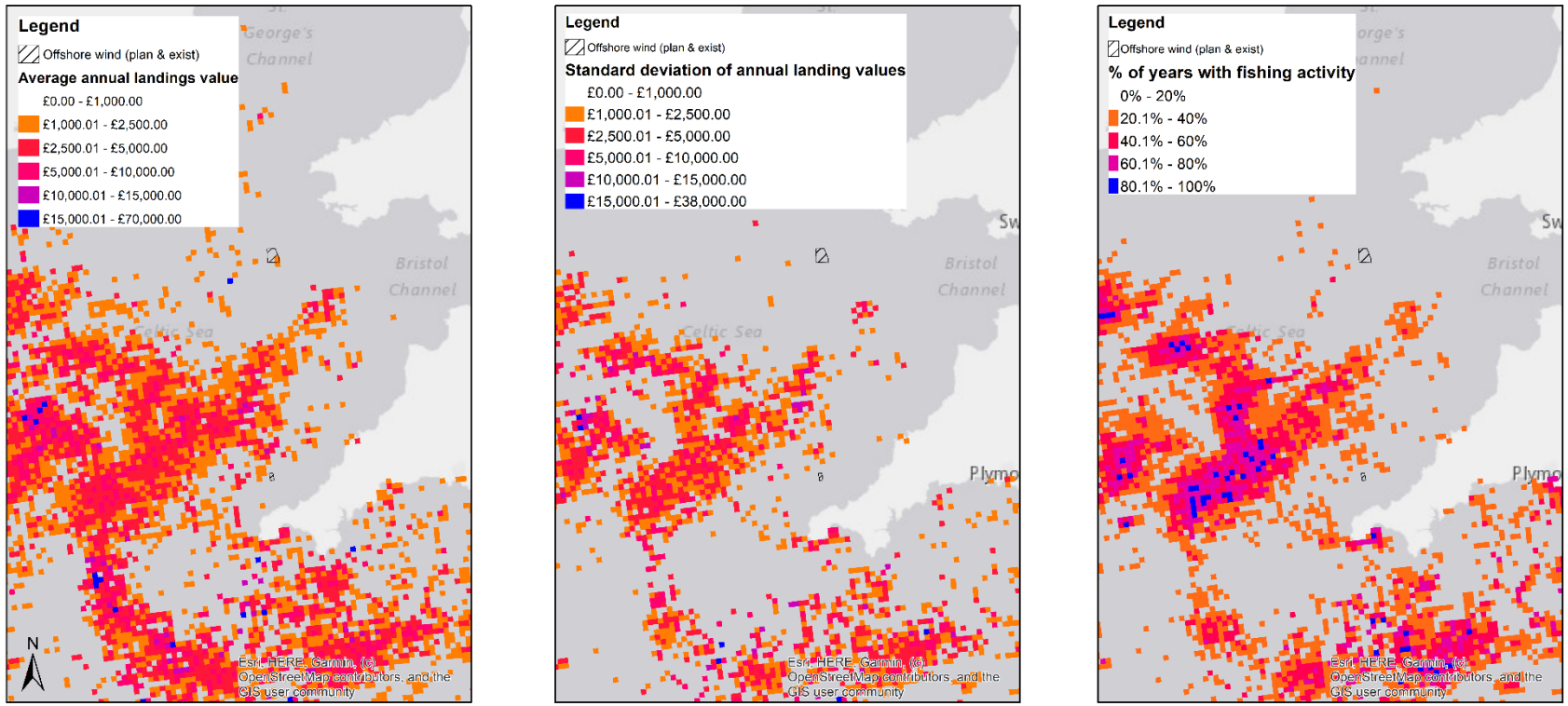

Figure 59: Example maps of Indicator 5a (Standard deviation of annual landing values) and Indicator 5b (Percentage of years the location was fished out of the 9 years here included) in comparison to long-term average annual landing values (2012-2020) for vessels using gillnet or entangled nets.

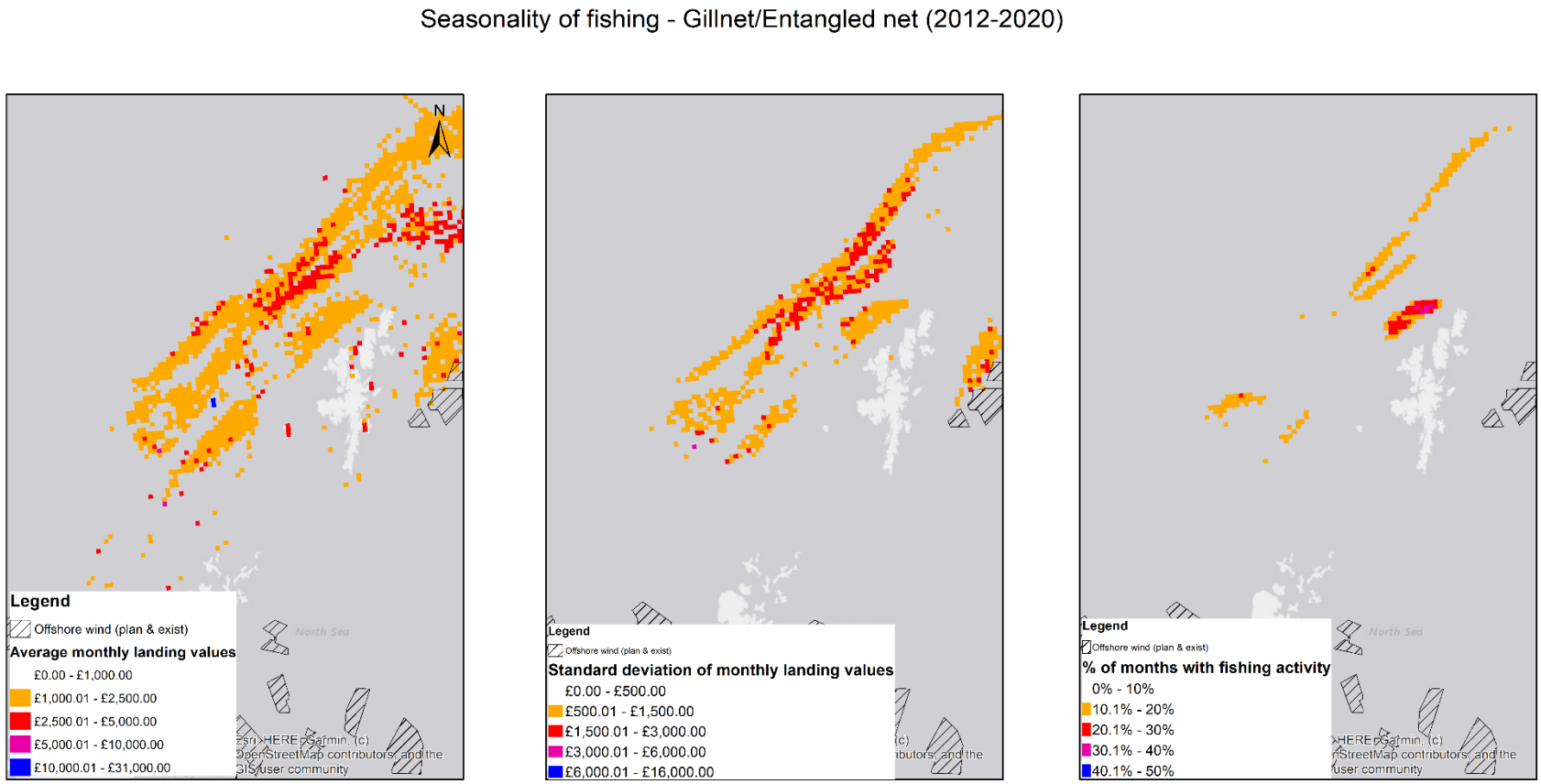

Figure 60: Example maps of Indicator 6a (Standard deviation of monthly landing values) and Indicator 6b (Percentage of months the location was fished out of the 9 years here included) in comparison to long-term average annual landing values (2012-2020) for vessel using gillnet or entangled nets.

Concentration of gear employed within the UK EEZ (Indicator 4b)

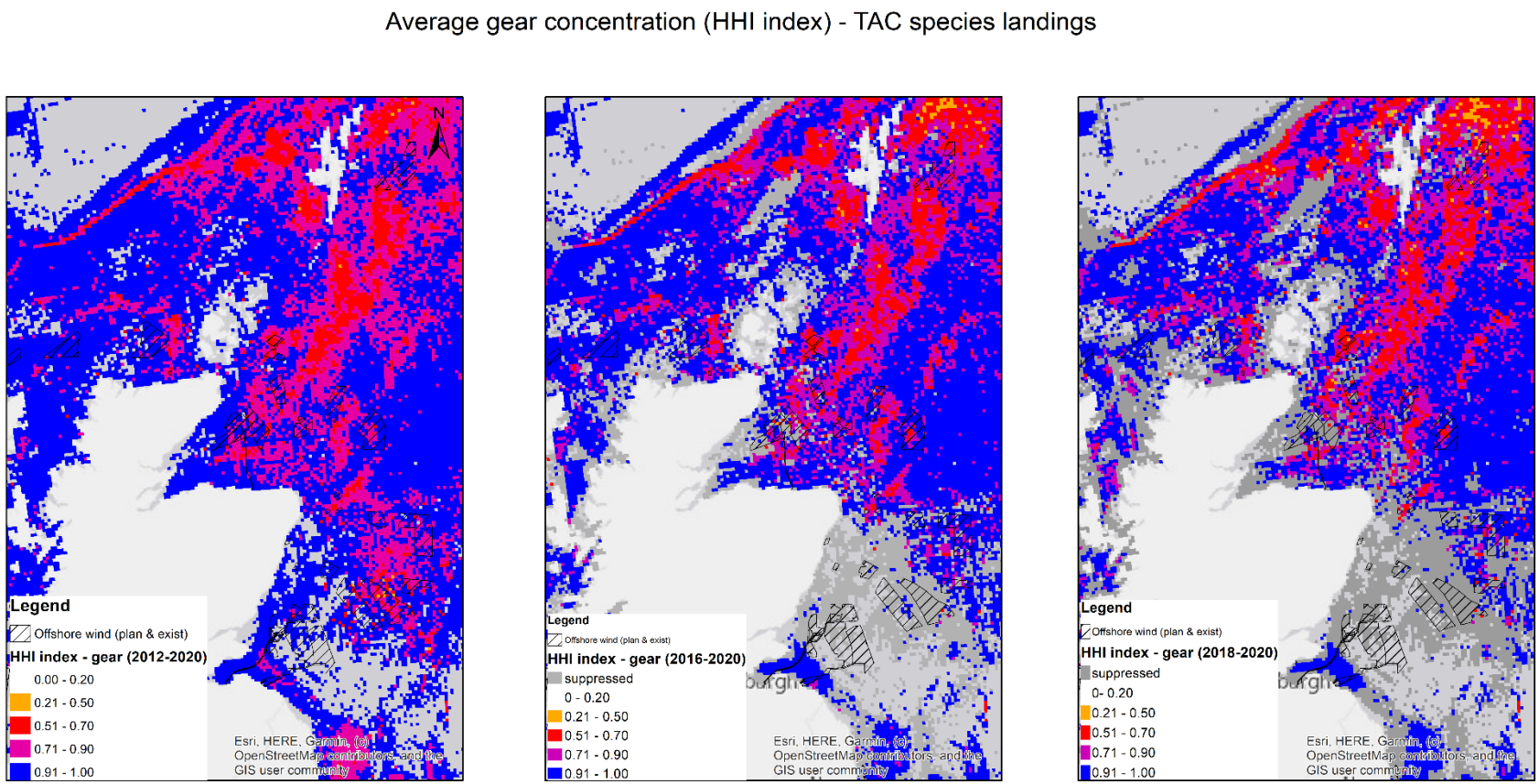

Figure 61: Average gear concentration (HHI) for 9-year, 5-year and 3-years average for vessels reported landings of species managed by quota at the time.

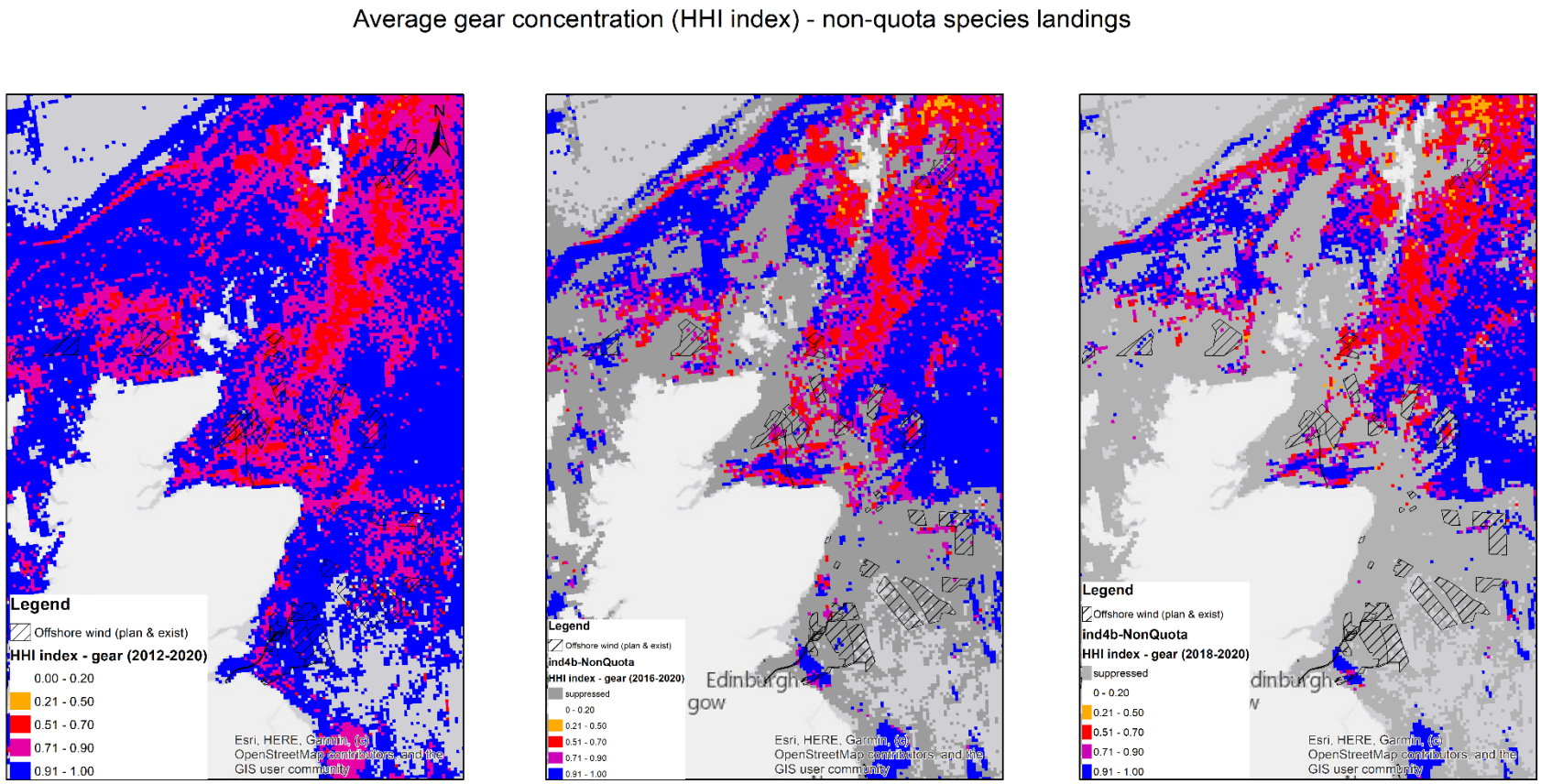

Figure 62: Average gear concentration (HHI) for 9-year, 5-year and 3-years average for vessels reported landings of species not managed by quota at the time.

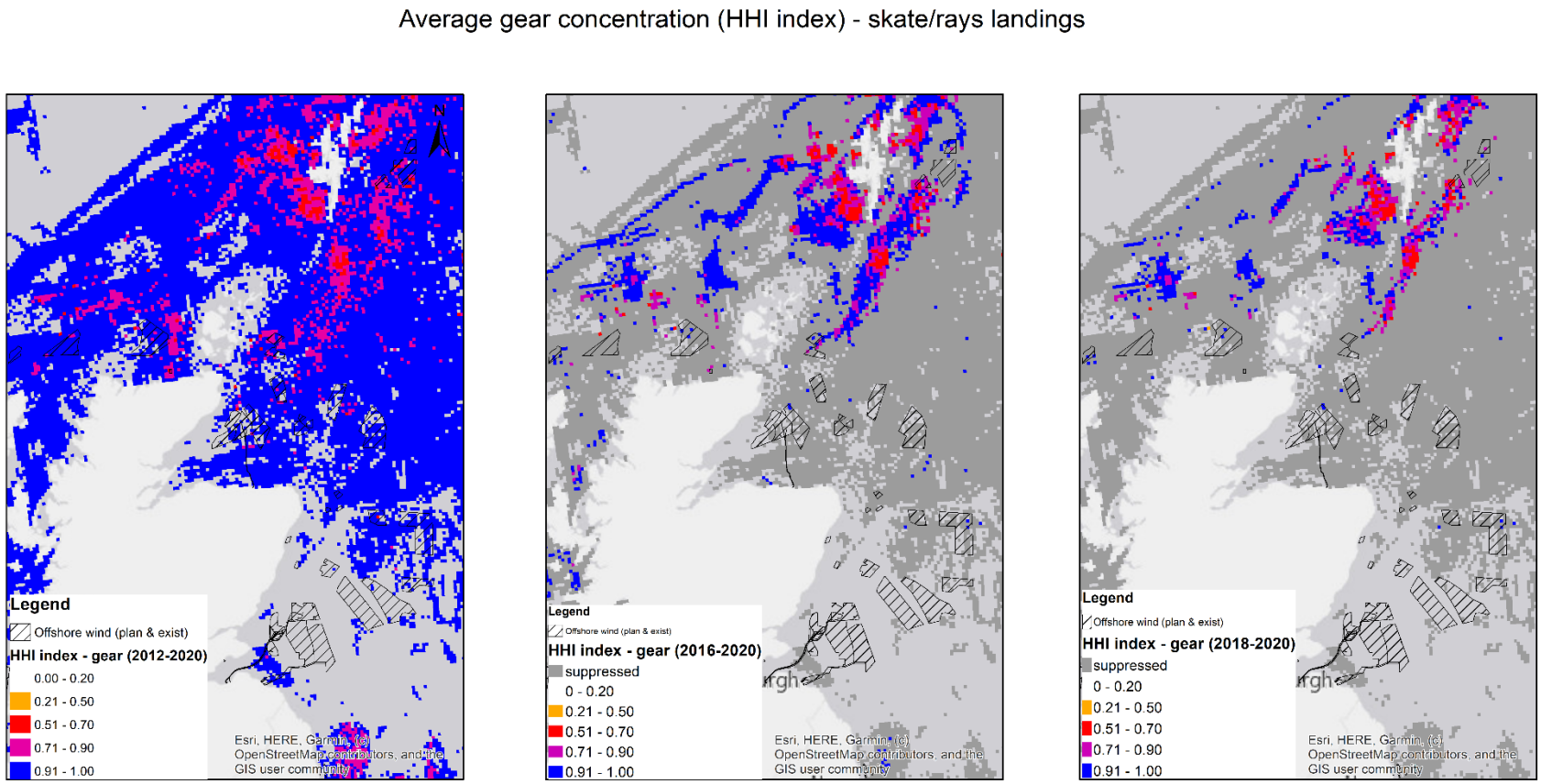

Figure 63: Average gear concentration (HHI) for 9-year, 5-year and 3-years average for vessels reported landings of skate and rays at the time.