Project UK: Nephrops

Ecosystem Scale Intensity Consequence Analysis (SICA)

August 2021

POSEIDON
AQUATIC RESOURCE MANAGEMENT

Report Information

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Abbreviations used

ETP	Endangered, threatened or protected
EUNIS	European Nature Information System
FIP	Fishery Improvement Project
FU	Functional Unit
ICES	International Council for the Exploration of the Sea
MSC	Marine Stewardship Council
PI	Performance indicator
RBF	Risk-based framework
SAR	Swept Area Ratio
SG	Scoring guidepost
SICA	Scale intensity consequence analysis
UoA	Unit of Assessments
VMS	vessel monitoring system

1. Introduction

1.1 Context

1.1.1 This report presents an ecosystem scale, intensity and consequence analysis (SICA) undertaken to inform the Project UK Round 2 UK Nephrops Fishery Improvement Project (FIP). The outcome status performance indicator (PI) of the Principle 2 ecosystem component (2.5.1) was assessed for the UK nephrops demersal trawl Unit of Assessments (UoA) to score 60-79 in the Marine Stewardship Council (MSC) pre-assessment completed in May 2019 (Poseidon, 2019). The following action was set within the Action Plan to work towards moving this score to a level of 80 or above:

> **Action 10.b:** Constitute expert group and conduct SICA analysis to determine main ecosystems and ecosystem services impacted by nephrops trawling across the UoAs under assessment.

1.1.2 The UK nephrops demersal trawl UoAs include both TR1 (mesh size ≥100 mm) and TR2 (mesh size 70-99 mm) trawl gears targeting nephrops Functional Units (FUs) in the North Sea, West of Scotland and Irish Sea.

1.1.3 This report was prepared by Poseidon Aquatic Resource Management Ltd (Poseidon) as part of ongoing support provided to the Project UK Round 2 Nephrops FIP.

2. Methodology

2.1 Approach

2.1.1 The Project UK secretariate (MSC) organised a SICA workshop, which was facilitated by Poseidon. Members of the Project UK Nephrops Steering Group with expertise in the ecosystem and/or the nephrops fishing industry were invited to join the SICA workshop, and to recommend additional ecosystem experts to be invited. The participants that attended the SICA workshop and formed this ecosystem expert group are provided in Appendix A.

2.1.2 Ahead of the workshop, the expert group was provided with guidance on the MSC ecosystem outcome status performance indicator and scoring guideposts (Appendix B); a SICA questionnaire (Appendix C); vessel monitoring system (VMS) data for otter trawl targeting nephrops (Appendix D) and additional guidance on consequence analysis (Appendix E).

2.1.3 During the workshop, each SICA question was discussed by the group, followed by real-time interactive voting using Mentimeter to answer multiple choice questions.

2.1.4 This report combines the Mentimeter voting results, identifies whether consensus was reached by the expert group, documents key points /discussions and further considers the research literature raised during the workshop. The conclusion for each question provides justification and rationale for the final answer chosen.

2.2 Objective

2.2.1 Within the MSC framework a SICA can be used to assess the ecosystem outcome status component using the risk-based framework (RBF) where there is not sufficient quantitative evidence to determine a score for the fishery. It can also be used where quantitative data is available as a means of obtaining a range of viewpoints and constructing the probability interpretation of the scoring guideposts (i.e., whether SG60, SG80 or SG100 are achieved). Undertaking a formal RBF is not proposed for this component, therefore the SICA methodology was used as a means to facilitate discussion and draw together expert judgement.

2.2.2 The objective of the workshop was to bring together experts in nephrops fishery and ecosystem interactions, and in doing so understand a range of viewpoints and expert judgement on the effect of the nephrops fishery on the ecosystem; collate research and evidence cited by participants; provide consensus around the scoring of ecosystem outcome status and therefore inform the direction of recommendations and future management.

2.3 Definitions

Definition of an ecosystem

2.3.1 The ecosystem component is defined as being the broad ecological community and ecosystem in which the fishery operates. Ecosystem is the fifth component of Principle 2 and care is required not to duplicate assessment of the four other Principle 2 components, including, primary and secondary species, habitats or endangered, threatened or protected (ETP) species, as well as the target species assessed under Principle 1.

2.3.2 Instead of focusing on one specific species or habitat (which would be assessed within these other Principle 1 and Principle 2 components), the ecosystem assessment considers wider structure, function and system-wide issues, primarily impacted indirectly by the fishery, including:

- Ecosystem structure;
- Trophic relationships;
- Biodiversity; and
- Community resilience.

Definition of serious or irreversible harm

2.3.3 Examples of instances where serious or irreversible harm may occur include:

- Trophic cascade caused by depletion of predators;
- Depletion of top predators caused by depletion of key prey species;
- Severely truncated size composition of the ecological community;
- Gross changes in the species diversity of the ecological community e.g., loss of species, major changes in species evenness and dominance; and
- Change in genetic diversity of species caused by selective fishing e.g., genetically determined change in parameters such as growth or reproductive output.

Definition of sub-components of the ecosystem

2.3.4 The SICA methodology requires delineation of ecosystem sub-components to determine where the greatest effect of the fishery on the ecosystem occurs. The specified ecosystem sub-components include:

- **Composition of species** in ecosystem – detectable changes in the identity of species within the ecosystem;
- **Functional group** - species that share similar suites of traits and provide a similar ecological function or service to the ecosystem;
- **Distribution of communities** – change in geographic range of communities which can impact community dynamics;
- **Trophic structure** – change in mean trophic level within the ecosystem. Species within the ecosystem, not specifically target species; and
- **Size structure** – change in biomass/number in each size class for each species. Species within the ecosystem, not specifically target species.

2.4 Steps for undertaking a SICA

2.4.1 The steps for undertaking a SICA are illustrated in Figure 2.1. This sequence has been followed in the order of questions developed within the SICA questionnaire (Appendix C).

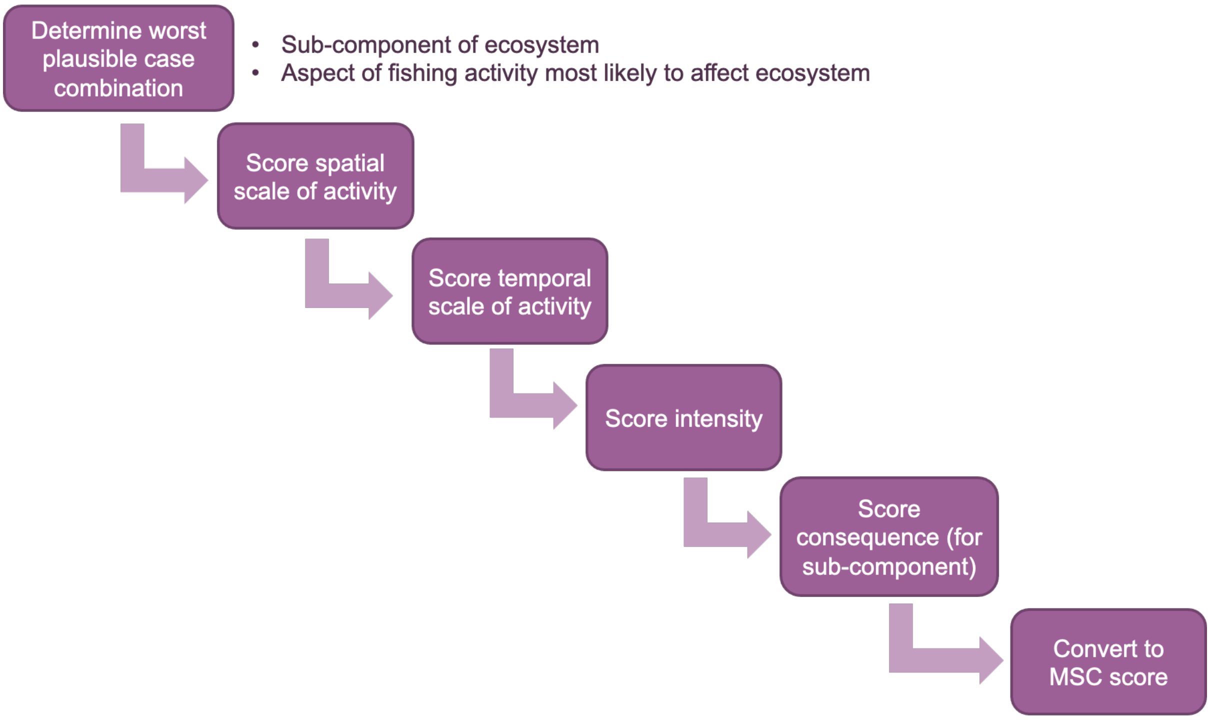

Figure 2.1: Steps for undertaking the Scale Intensity Consequence Analysis

2.5 Structure of the report

2.5.1 The remaining sections of this report are structured as follows:

- Discussion and conclusion: is presented for each question of the SICA questionnaire, detailing the discussion points and expert judgements provided during the workshop, as well as details of any further research cited. A conclusion for each question provides the overall justification for the answer chosen.
- SICA overview: presents the overall conclusions and justifications for the SICA in MSC table format.
- Recommendations: provides recommendations for updates to, and next steps within, the Action Plan.

3. Results and discussion

3.1 Geographic area of the ecosystem(s)

Question 1

3.1.1 Define the geographic area of the ecosystem(s) and specify reason for this choice. Options provided:

- One overall ecosystem for all waters targeted by the fishery
- Three ecosystems: North Sea, West of Scotland, Irish Sea
- More than three ecosystems (by functional unit or other split)

Results and discussion

3.1.2 Project UK nephrops includes 12 Functional Units (FUs) across the North Sea (FUs: 5-10 & 34), West of Scotland (FUs 11-13) and Irish Sea (FUs 14-15), as shown in Figure 3.1.

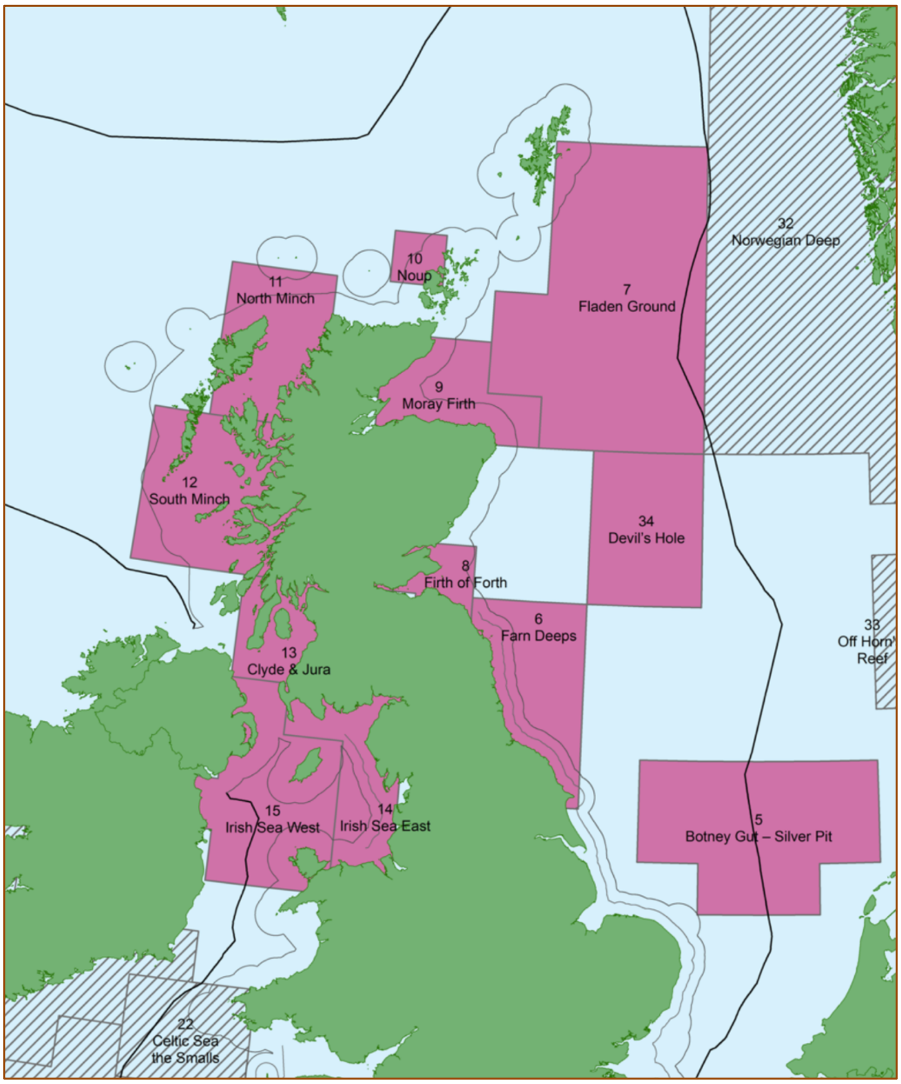

Figure 3.1: Nephrops Functional Units (FUs) included in Project UK

3.1.3 As defined by ICES, the West of Scotland and Irish Sea are part of the Celtic Seas ecoregion and the North Sea is part of the Greater North Sea ecoregion (Figure 3.2).

Figure 3.2: The ICES ecoregions (ICES, 2021)

3.1.4 Defining the ecosystem geographic areas is important because it will impact the scores of later questions when considering the overlap of fisheries on a spatial and temporal scale.

3.1.5 As described in Section 2, the working definition of an ecosystem is a broad ecological community and ecosystem in which the fishery operates. Generally, existing full assessments consider the entire ecosystem that the fishery operates within, without splitting the ecosystem component into separate geographic areas. However, there is scope and justification to split the UoAs into a number of ecosystems, especially with multiple stocks under assessment across a wide area. In such a case, each ecosystem would be assessed and scored separately.

3.1.6 The results of the expert working group interactive voting for division of the ecosystem by geographic area is shown in Figure 3.3. It is agreed that the ecosystem component should not be considered as one overall ecosystem and should be split into different ecosystem areas.

3.1.7 The proposed option of three ecosystems would be divided as: North Sea, West of Scotland and Irish Sea. The expert group noted that there is connectivity between the West of Scotland and Irish Sea, specifically citing larval connectivity between the Clyde and Irish Sea.

3.1.8 The three area separation (North Sea, West of Scotland and Irish Sea) aligns with ICES Divisions and is regularly used to define stock areas for other fish species. However, taking larval connectivity into account, and the ecoregions defined by ICES (Figure 3.2), it would be logical to split the ecosystem areas into two: Western region (including West of Scotland and Irish Sea) and Greater North Sea.

3.1.9 This allows consideration of variation of specific attributes or features of these ecosystems, including Priority Marine Features (PMFs), while also providing a manageable and realistic scale for potential future ecosystem management. It aligns with the spatial units of ecoregions defined by ICES, which are used to synthesize the evidence for the ecosystem approach, and are the basis to which ICES provide regional advice and develop ecosystem monitoring programmes.

3.1.10 This approach also allows for recognition of specific functional units within each of the defined ecosystems, but ensures that connectivity characteristics within the wider ecosystem is not lost e.g., larval connectivity between the Clyde (in the West of Scotland) and Irish Sea.

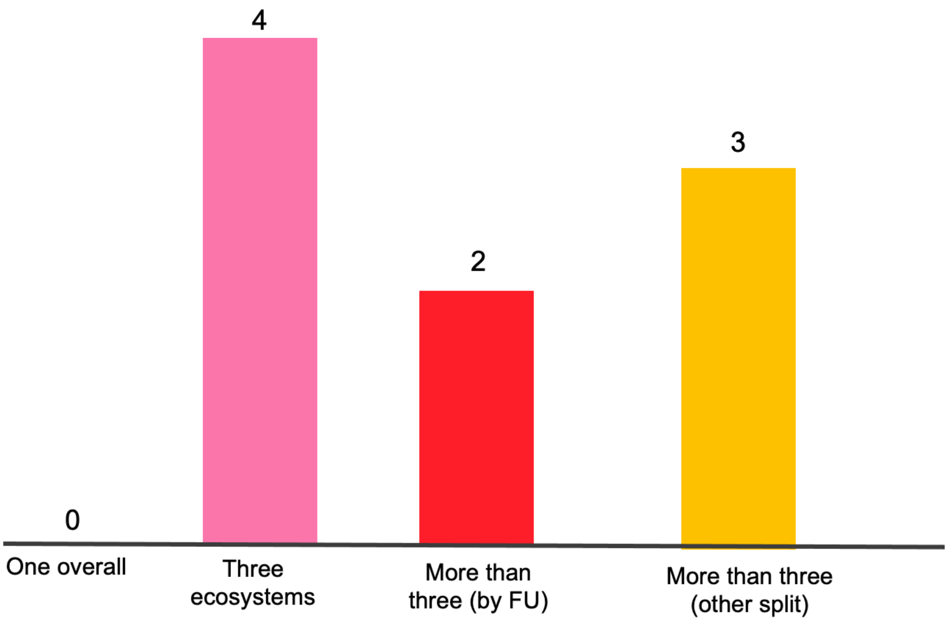

Figure 3.3: Expert working group interactive voting for division of the ecosystem by geographic area(s)

3.1.11 Arguments for splitting the ecosystem component into more than three areas (including by functional unit, or some other areal split) considered the variation of exploitation and environment across the functional units, making biogeographic sense to split by functional unit. It was further noted that the lack of data to define ecosystem heterogeneity brings challenges in predicting the extent of impacts. Furthermore, the high degree of variability in habitat, structure and depth will bring variation in the extent of potential recovery.

3.1.12 If the ecosystem component was split by more than three, but not by functional unit, it was recognised that further review of different areas' characteristics would be required before a decision could be made on appropriate delineation, noting also that data deficiency may hinder more fine-scale management.

Conclusion

3.1.13 Overall, it is considered appropriate to split the ecosystem component into geographic areas that align with the defined ICES ecoregions as follows:

- Western region: including functional units in the West of Scotland, Irish Sea and Noup; and
- Greater North Sea: including functional units in the North Sea.

3.1.14 Nephrops fisheries are highly specific in targeting muddy sediments, and this should be given due regard when considering the spatial and temporal overlap of the fishery i.e., it is the muddy habitat within each of the ecoregions that forms the ecosystem in which the fishery operates.

3.1.15 The ecoregions and nephrops functional units are presented in Figure 3.4.

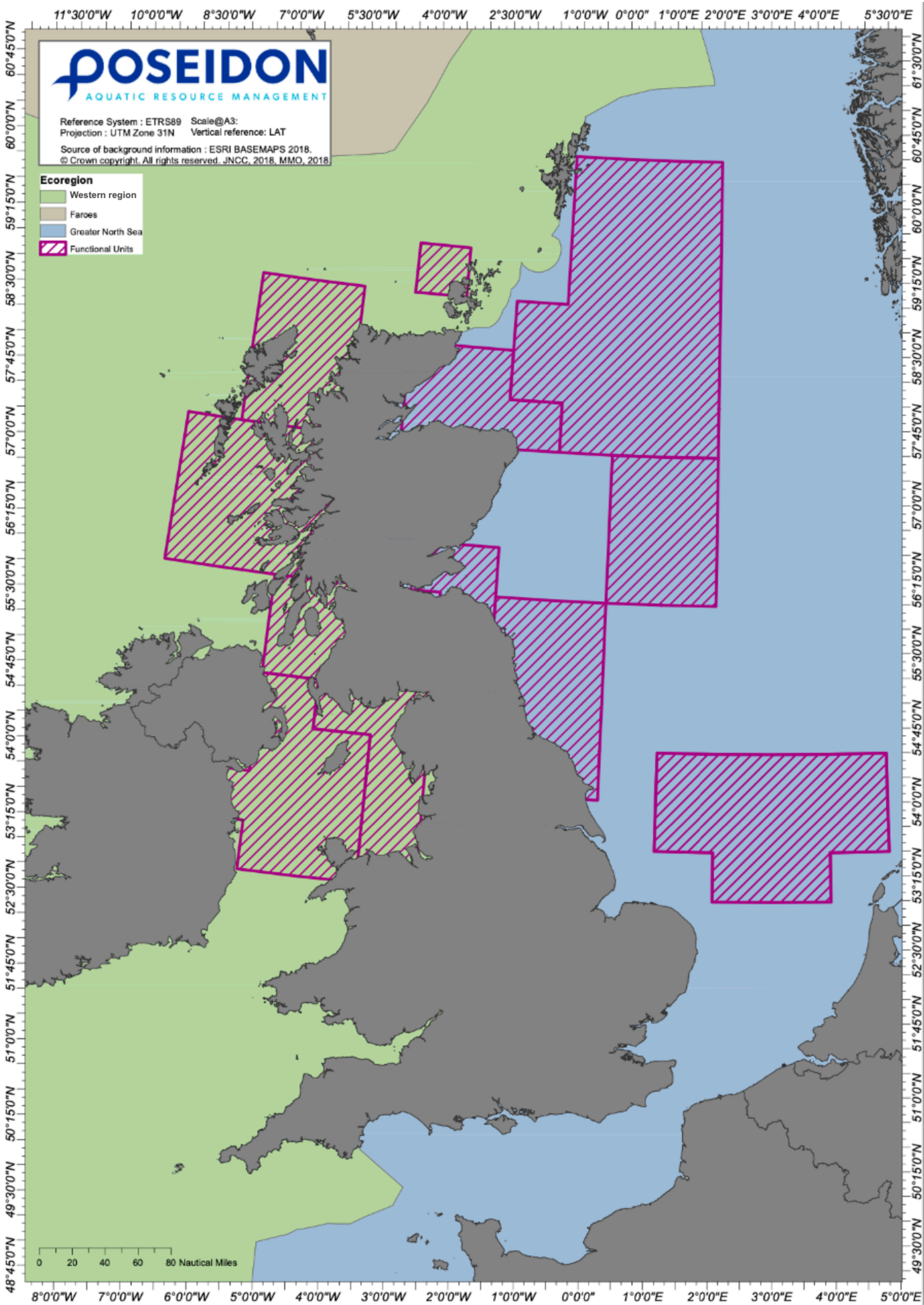

Figure 3.4: Nephrops functional units within the Western and Great North Sea ecoregions

3.2 Ecosystem sub-components affected by the fishery

Question 2 & 3

3.2.1 What elements of the ecosystem do you think may be affected by the fishery?

Question 2: Please rank elements 1 to 5, where 1 is most affected and 5 is least affected.

Question 3: Please choose one option as the most likely to be affected.

- Composition of the species
- Functional group
- Distribution of communities
- Size structure
- Trophic structure
- Other (specify)

Results and discussion

3.2.2 The expert group agreed that ranking ecosystem sub-components and choosing which is more affected than the other is challenging due to the intrinsic interlinking of sub-components, where changes to one is likely to stimulate changes in the other sub-categories. The results of the ranking of sub-components is shown in Figure 3.5 and selection of most affected shown in Figure 3.6; Table 3.1 presents a combined ranking for the ecosystem sub-components based on combining results from both questions.

3.2.3 The broad range of responses, indicate that all sub-components are considered important for this fishery. Although, this may also reflect the specific scope of interest for attendees present.

3.2.4 Overall, Table 3.1 indicates that composition of species and distribution of communities ranked highest when combining the answers to both questions.

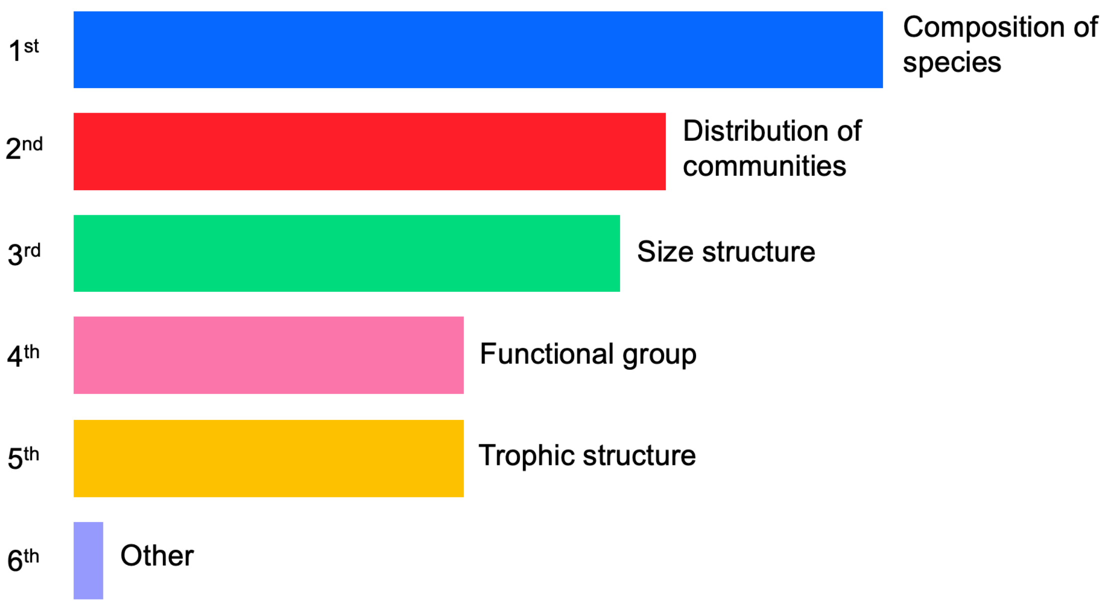

Figure 3.5: Expert working group interactive voting for ranking of ecosystem sub-components affected

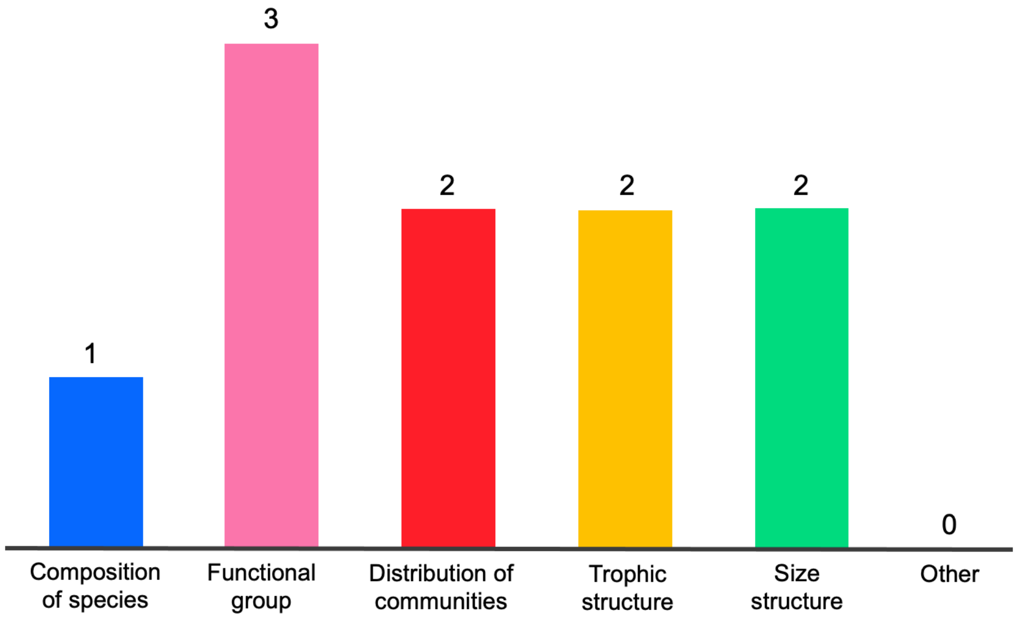

Figure 3.6: Expert working group interactive voting for most affected ecosystem sub-component

Table 3.1: Combined ranking for questions 2 and 3

	Question 2	**Question 3**	**Overall**
Composition of the species	Ranked first: 5 points	Third place: 3 points	8 points
Distribution of communities	Ranked second: 4 points	Joint second: 4 points	8 points
Size structure	Ranked third: 3 points	Joint second: 4 points	7 points
Functional group	Ranked joint fourth: 2 points	First place: 5 points	7 points
Trophic structure	Ranked joint fourth: 2 points	Joint second: 4 points	6 points

3.2.5 Hidink *et al.* (2017) comprehensively documents how bottom contact fishing gear that is trawled across the seabed causes a range of effects including;

- Resuspension of sediments;
- Reduction in topographic complexity and biogenic structures;
- Reduction in faunal biomass, numbers and diversity;
- Selection for communities dominated by fauna with faster life histories; and
- Production of carrion that attracts scavenging and predatory epifaunal species.

3.2.6 Overall, these effects lead to changes in the community production, trophic structure and function.

3.2.7 In relation to composition of species, the expert group highlighted the impact of nephrops trawling on erect macrofauna and in reducing the topographic heterogeneity of the seabed (i.e. 'smoothing' of the seabed). Removal of nephrops also changes the composition of the size class, which then impacts the degree of burrowing and substrate bioturbation and oxygenation. In that scenario this potentially alters the species composition of the burrowed mud. The varying impact on receptors was also highlighted, comparing the level of impact and recovery for mobile transitory epifauna compared to sessile infauna.

3.2.8 Changes in species composition as a result of demersal otter trawling may occur at a widespread scale, and its consequences are likely to affect trophic structure. Over time marked differences in the benthos can be found in fished and unfished areas. Regular bottom contact trawling gear may prevent development of emergent epifauna within the seabed, such as sea pens and fireworks anemones. While this affects both composition of species and distribution of species, it also limits the potential for such species to inhabit regularly fished area.

3.2.9 Functional group was voted the most important single ecosystem sub-component to be effected by the nephrops fishery. Noting the difference between functional unit (the defined stock areas for nephrops biological stocks) and function group (species that share similar suites of traits and provide a similar ecological function or service to the ecosystem). Aspects considered important in relation to functions group included:

- The endemic diversity within the nephrops functional units may compare with other units and fisheries.
- The degree of ecosystem engineering the biodiversity of each sub-component may accommodate.

3.2.10 While it is recognised that all sub-components are potentially impacted, research cited during discussion (including Hiddink *et al.,* 2017; and Sciberras *et al.,* 2018) focus on the quantitative assessment of reduction in benthic community numbers, biomass and abundance.

Conclusion

3.2.11 Overall, given the results from the workshop voting, coupled with the scientific evidence that quantifies the impact, it is considered that **composition of species** and **distribution of communities** are the two most pertinent ecosystem sub-components affected by the fishery.

3.3 Aspect of fishing activity causing the affect

Question 4

3.3.1 What aspect of fishing activity is most likely to affect the ecosystem? *Please choose one option.*

- Fish removal (i.e. removal of the target species and/or other species caught)
- Interaction with the habitat
- Loss of fishing gear
- Bait collection (if relevant to the fishing industry)
- Anchoring gear (if relevant for fishing)
- Boat mooring (if relevant for fishing)

Results and discussion

3.3.2 The expert group consider fish removals and gear interaction with the habitat to be the aspects of the fishing activity to affect the ecosystem. The voting was relatively evenly split across these two aspects, with **interaction with the habitat** obtaining one more vote than fish removal (Figure 3.7).

3.3.3 The gear under assessment includes TR1 and TR2, so a range of demersal fish species are targeted and removed, including existing certified fisheries for haddock, hake, saithe and plaice. Removal of nephrops itself will cause interaction with the habitat, by affecting the number and extent of nephrops burrows being created.

3.3.4 A study in the Western Irish Sea Mud Belt found evidence that bottom trawling has significantly changed the sedimentation regime and has removed an estimated 20-50cm of the upper seabed (Coughlan et al., 2015). Overall, it is considered that physical disturbance from bottom contact gear is most likely to affect the ecosystem condition.

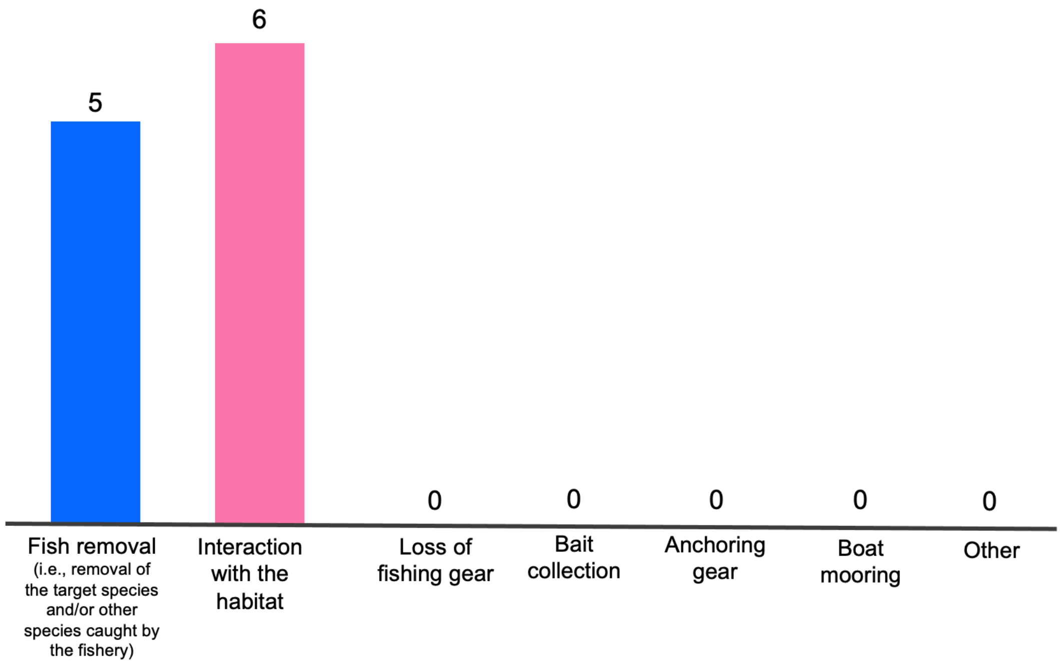

Figure 3.7: Expert working group interactive voting for aspect of fishing activity causing the affect

Conclusion

3.3.5 The aspect of fishing activity most likely to affect the ecosystem is the **interaction of the fishing gear with the habitat**.

3.4 Spatial scale of overlap

Question 5

3.4.1 Spatial scale: what is the scale of overlap between the fishery and the element of the ecosystem that is most likely to be affected by it? *Please select one option based on your expert judgement.*

- Less than 1% overlap
- 1-15% overlap
- 16-30% overlap
- 31-45% overlap
- 46-60% overlap
- Over 60% overlap

Results and discussion

3.4.2 The VMS data presented in Appendix D indicates the spatial distribution of UK and EU vessels 12m and over in length targeting nephrops in 2017. This indicates a variable spatial overlap across different functional units, but highlights that no one FU is fished in its entirety.

3.4.3 The interactive voting during the workshop ranged from 31-45% overlap to >60% overlap; the latter of which received the majority (60%) of the votes (Figure 3.8). Those voting for >60% highlighted that this related to the 'fishable' elements of the ecosystem, rather than across the ecoregion as a whole, i.e., the nephrops fishery overlaps with >60% of the areas that are fishable, rather than >60% of the wider ecoregion.

3.4.4 Concern was raised for the overlap of trawl fishery on subtidal mud and seapens and burrowing megafauna seabed habitat.

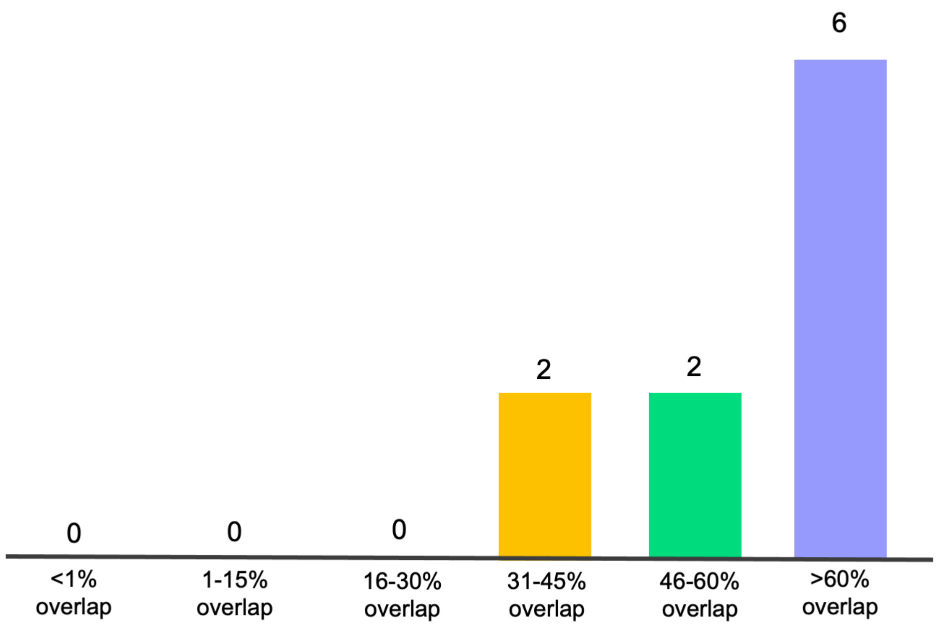

Figure 3.8: Expert working group interactive voting for spatial scale of overlap

3.4.5 A masters student undertook work to map the footprint of the fishery across habitats, with focus given to PMFs. While this masters project did not draw conclusive findings, it has prompted further work to be sought to better understand the effect of nephrops trawling on commonly encountered habitats and vulnerable marine ecosystems (VMEs). This is being taken forward under Action 9: Habitats of the Action Plan.

3.4.6 Without duplicating effort anticipated to be carried out as part of this future habitats project, information that is readily available includes Swept Area Ratio (SAR) data and broad scale habitat mapping. The SAR for demersal trawl gear targeting nephrops in 2017, for all EU and UK vessels 12m and over in length is presented in Figure 3.9 and predicted EUNIS habitats containing mud are shown in Figure 3.10.

3.4.7 It is noted that while trawling gear does not overlap the entirety of any of the functional units, the FUs are defined based on ICES rectangles, rather than habitat type. Studying the fishery SAR alongside the distribution of mud habitats it is clear that deep circalittoral mud and circalittoral fine mud are key habitats that are highly targeted by the fishery.

3.4.8 Other research (Amoroso et al., 2018, as cited in Mazor et al., 2021) has shown that European marine regions, including the North Sea, have trawl footprints covering >50% of their continental shelf.

Conclusion

3.4.9 Based on VMS data and surface SAR data specific to nephrops trawling by vessels 12m and over, together with habitat mapping, it can be concluded that the fishery interacts with a high proportion of the available muddy habitats within both the Western and Greater North Sea ecoregions.

3.4.10 Considering the footprint of the fishery, distribution of muddy habitat, together with the responses from the expert group workshop, it is considered that the spatial scale of the fishery overlaps with >60% of the nephrops ecosystem in both the Western and Greater North Sea ecoregions.

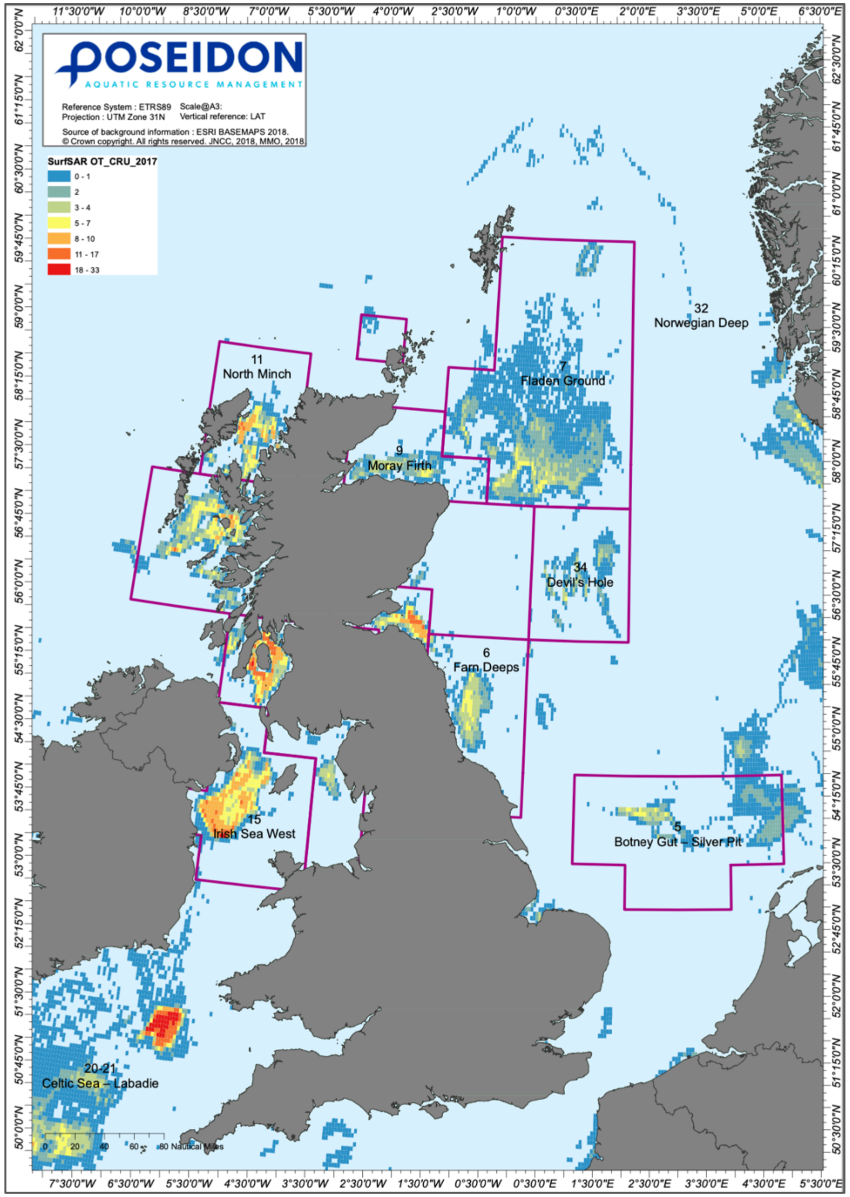

Figure 3.9 Surface Swept Area Ratio for demersal trawl gear targeting nephrops in 2017, for all EU and UK vessels 12m and over in length (data source: ICES, 2020)

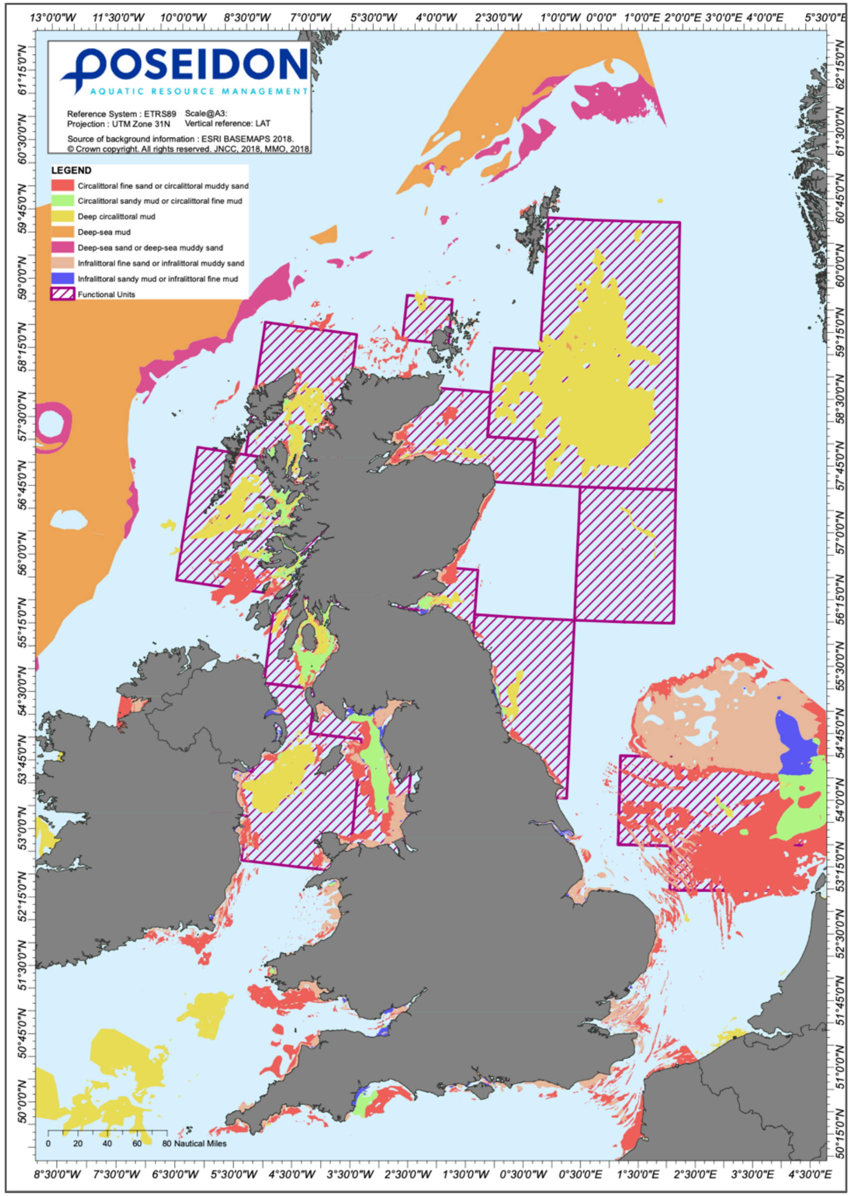

Figure 3.10 Predicted EUNIS habitats containing mud

3.5 Temporal scale of overlap

Question 6

3.5.1 Time scale: how often does the fishery interact with the element of the ecosystem that is most likely to be affected by it? *Please select one option based on your expert judgement.*

- 1 day every 10 years or so
- 1 day every few years
- 1-100 days per year
- 101-200 days per year
- 201-300 days per year
- 301-365 days per year

Results and discussion

3.5.2 It was agreed by the expert group that the swept area ratio is a more relevant measure of temporal interaction than fishing hours. The ratio is calculated by dividing the number of square kilometres fished by cell area; if the ratio is 1 then the whole cell area has been fished /swept once. The calculation uses VMS data and is based on fishing hours and gear used.

3.5.3 The swept area ration data for nephrops trawling by EU and UK vessels ≥12m is presented in Figure 3.9. All nephrops functional units in the Greater North Sea ecoregion recorded a maximum SAR of 7 (i.e., the area has been swept 7 times during that annual period); expect for the Firth of Forth, where the highest SAR recorded was 17. Functional units in the Western ecoregion generally had higher SAR values compared to the North Sea; the Clyde and Jura FU recorded SARs of 17 across much of the area fished; as did the Irish Sea West, which also had small areas peaking at a SAR of 33.

3.5.4 The industry members of the expert group considered that the temporal overlap of nephrops vessels operating in the North Sea may by up to 200 days, based on the number of days operating and the hours per day engaged in active fishing. The expert group agreed that interactions will be highly specific according to functional units and that in some areas there are many vessels are under 12m so will not be included in VMS data, and not represented within the SAR mapping.

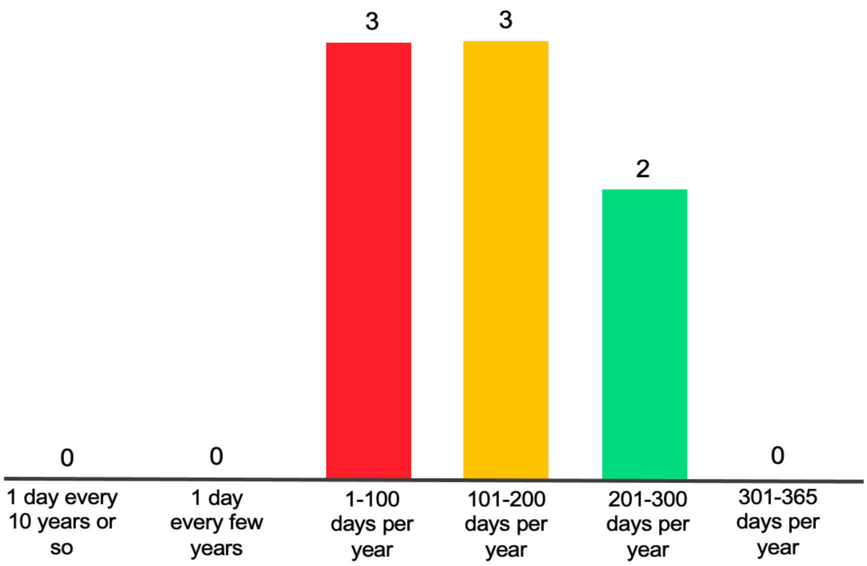

Figure 3.11: Expert working group interactive voting for temporal scale of overlap

Conclusion

3.5.5 The temporal scale of interaction of the fishery with the ecosystem is considered to answer the question: How often does the fishery interact with the nephrops ecosystem? Rather than how often is one specific grid area of the habitat fished.

3.5.6 Based on information provided during the workshop on the average swept area ratio, industry knowledge on level of activity at specific fishing locations, together with VMS data limitations (i.e., the under 12m fleet not being represented within VMS), it is considered that the temporal scale of overlap is 101-200 days per year. This accounts for uncertainty and is considered to be precautionary.

3.6 Intensity of the interaction

Question 7

3.6.1 Intensity: How intense is the interaction of the fishing industry with the element of ecosystem that is most likely to be affected by it? *This relates to the ecosystem sub-component identified in Q.3. Please select one option based on your expert judgement.*

- Negligible - Remote probability of the effect of the activity detected at any spatial scale or temporary;
- Minor – Minor activity occurs rarely or in some restricted places, and evidence of activity even at these scales it is rare;
- Moderate - Moderate activity detection on a wider spatial scale or obvious detection but local;
- Major – The detectable evidence of activity occurs reasonably often on a broad spatial scale;
- Severe - Easily detectable localized evidence of activity and widespread and frequent evidence of activity;
- Catastrophic Local or regional evidence of activity or continuous and widespread evidence.

Results and discussion

3.6.2 The expert group highlighted evidence of impacts on ecosystem sub-components from Rijnsdorp et al 2020, which found that approximately 10% of biota are removed after trawling, half of which are scallops. It was noted that from available underwater footage, it is rare not to see flattening or gauging of the seabed from nephrops trawlers, especially in relation to twin riggers.

3.6.3 The level of severity does depend on the status of the ground and the previous levels of interaction, e.g., the impact to an area frequently swept will be very different to the impact to a previously unfished area of burrowed mud with potential presence of fireworks anemone and tall sea pens.

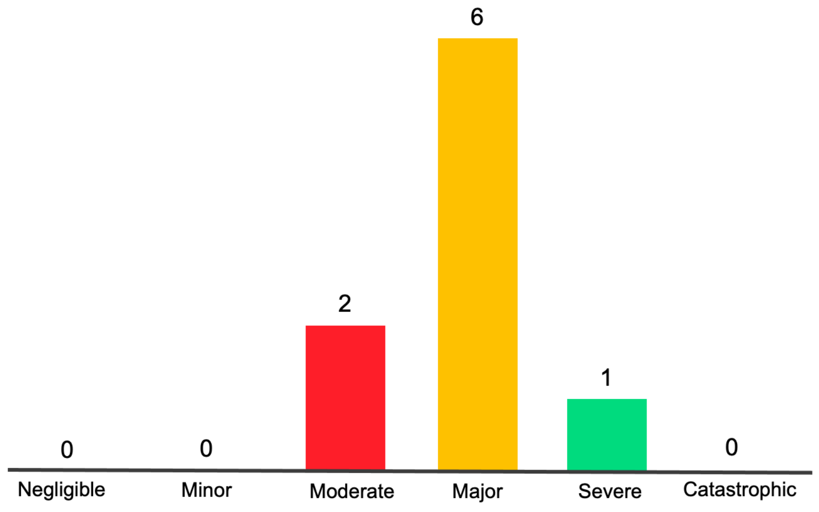

Figure 3.12: Expert working group interactive voting for intensity of the interaction

Conclusion

3.6.4 Overall, it was considered by the expert group that detectable evidence of nephrops trawling occurs reasonably often and on a broad spatial scale that overlaps with the distribution of burrowed mud habitat, where the target species is solely found. The intensity of the interaction is therefore deemed to be major.

3.7 Consequence of the impact

Question 8

3.7.1 Consequence: what do you think are the consequences of the impact of the fishery on the aspect of the ecosystem most likely to be affected? *This relates to the element identified in Q.3. Please see Annex A for further guidance on justifications relevant for each option.*

- Interactions are unlikely to be detectable against natural variation (SG100);
- Interactions are likely to cause up to 5% change in characteristic; impact recovery is likely to take up to 5 years. (SG80);
- Interactions are likely to cause up to 10% change in characteristic; impact recovery is likely to take up to 20 years. (SG60);
- Interactions are likely to cause greater than 10% change in characteristic; impact recovery is likely to more than 20 years

Results and discussion

3.7.2 The expert group discussed available research that quantifies the level of removal of biota post trawling events.

3.7.3 The exert group highlighted the challenges of assessing the proportion of interaction in combination with the recovery time, as this the impact is very species specific and variable across regularly fished areas compared to unfished areas of mud. It is noted that the proportion of biota removal (e.g., 10%) varies in severity depending on the species composition within that 10%. This is considered within the Benthic Ecosystem Fisheries Impact Study (BENTHIS) undertaken by Rijnsdorp et al. (2017), which found that:

> *Fishers concentrate their activities in only a part of their total fishing area. These core fishing grounds are characterised by a relative low status (high impact). Additional fishing in these core grounds have only a small impact. In the peripheral areas where fishing intensity is low, additional fishing will have a much larger impact. Hence, shifting trawling activities from the core fishing grounds to the peripheral areas will increase the overall impact. Shifting activities from the peripheral grounds to the core will reduce the overall impact.*

3.7.4 Other points raised by the expert group included:

- Evidence of longer-term impacts on seabed sediments (biogeochemistry and topography) and faunal communities due to impact of bottom-contacting gear and low natural disturbance levels
- Large variation by FU e.g., comparing Irish Sea and Noup, and there has been no quantification of the scale of the effect on trophic levels.
- The need for balancing the scale effect with other interactions from other fisheries such as effecting trophic levels e.g. whitefish fisheries removing predators of nephrops.
- There is a large amount of heterogeneity in terms of energetics and natural disturbance regimes. These could give some indication of the rates of change in these systems and it may be that for some the recovery could be quick (12 month) where for others it may take much longer.

3.7.5 The results of the interactive voting are presented in Figure 3.13, which shows that 78% of attendees consider that the interactions of the fishery with the ecosystem are likely to cause

10% change in the ecosystem sub-component, with impact recovery taking up to 20 years. This answer was selected for all of the different ecosystem sub-components that were considered the most affected by the fishery.

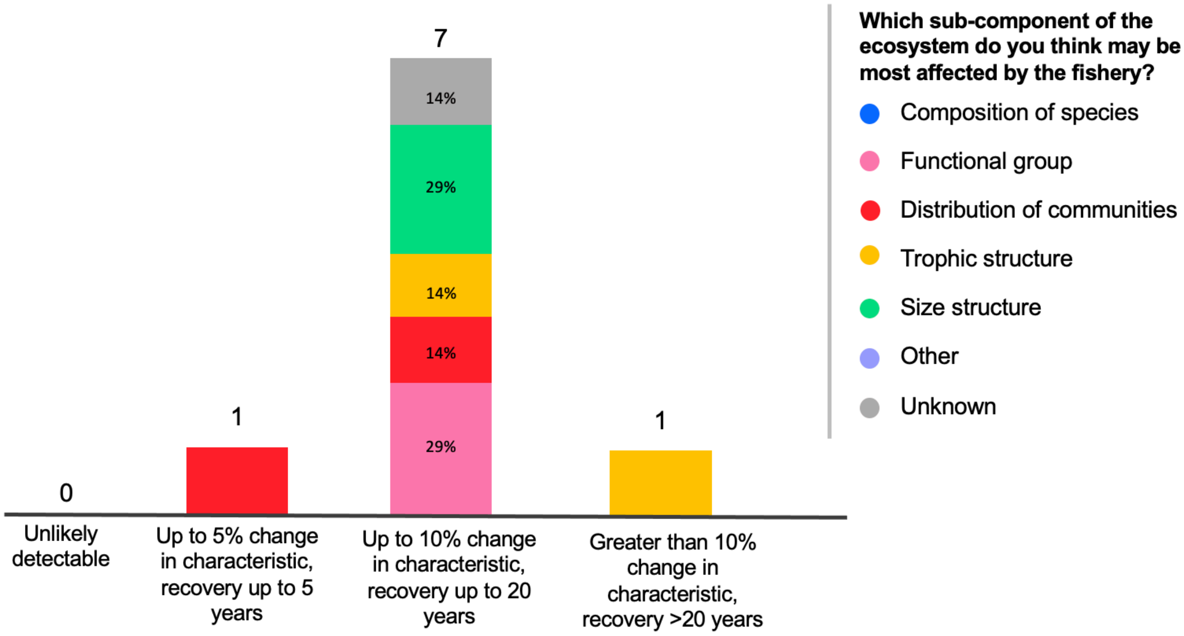

Figure 3.13: Expert working group interactive voting for consequence of the impact (figure is colour coded based on the answers provided for question 3)

3.7.6 Hiddink et al. (2017) found through meta-analysis that the reduction in benthic community numbers for each unit increase in trawling frequency were 5.5% (at 1% gravel content) for typical otter trawling gear. The study found benthic community reduction to increase with higher gravel content.

3.7.7 Overall otter trawls caused the least depletion compared to the other gears investigated (including beam trawl, towed dredge and hydraulic dredge). Otter trawls removed 6% of community biomass and abundance per pass, penetrating the seabed on average 2.4 cm (Hiddink et al., 2017, SI Appendix, Table S4).

3.7.8 Sciberras et al., (2018) found (also through meta-analysis) that mean initial response in community abundance to otter trawl per gear pass was -3% (ranging from -32% to +38%) and the time to recover was within days. The initial impact of otter trawls reduced community species richness by 9% (-22% to +6%) and the time to recover was 10 days.

3.7.9 Recovery rates depend on the level of active movement of individuals from adjacent habitats (including scavenging species), recruitment of new individuals and growth of surviving biota.

3.7.10 Median recovery rates post-trawling ranged from 1.9 to 6.4 years (Hiddink et al., 2017).

3.7.11 Sessile and low mobility biota with longer life-spans such as sponges, soft corals and bivalves took much longer to recover after fishing (>3 year) than mobile biota with shorter life-spans such as polychaetes and malacostracans (<1 year) (Sciberras et al., 2018).

Conclusion

3.7.12 The consequence of the fishery interactions with the ecosystem are considered likely to cause up to 10% change in the sub-component characteristic, with the impact likely to take up to 20 years to recover.

3.7.13 This meets the SG60 SICA requirement. The SG80 and SG100 are not met.

4. SICA overview

<table>
<tr><th>2.5.1 Ecosystem</th><th>Spatial scale of fishing activity</th><th>Temporal scale of fishing activity</th><th>Intensity of fishing activity</th><th>Relevant subcomponents</th><th>Consequence score</th></tr>
<tr><td rowspan="4">TR1 and TR2 trawling gear targeting nephrops in mud habitats within the Western region and Greater North Sea</td><td rowspan="4">6
[>60%]</td><td rowspan="4">4
[101-200 days]</td><td rowspan="4">4
[Major]</td><td>Species composition</td><td>60</td></tr>
<tr><td>Functional group composition</td><td></td></tr>
<tr><td>Distribution of the community</td><td>60</td></tr>
<tr><td>Trophic size/structure</td><td></td></tr>
<tr><td>Justification for spatial scale</td><td colspan="5">VMS data and surface swept area ratio data for trawling vessels (≥12m in length) targeting nephrops have been reviewed against habitat mapping available for muddy habitats (including deep circalittoral mud and circalittoral fine mud). This indicates that the fishery interacts with a high proportion (>60%) of the available muddy habitats within both the Western and Greater North Sea ecoregions.</td></tr>
<tr><td>Justification for temporal scale</td><td colspan="5">Surface SAR data indicates that specific areas within each functional unit in the North Sea are typically swept up to 7 times in one annual period, except Firth of Forth which recorded a maximum SAR of 17. The SAR values in the Western ecoregion are generally higher, with a SAR of up to 17 in most functional units, peaking at 33 in Irish Sea West.

Fishing industry knowledge indicates that vessel may be operating up to 200 days across specific functional units. It is also noted that SAR data does not account for vessels without VMS (<12m in length).

Overall, accounting for uncertainty, and taking a precautionary approach, the temporal scale of overlap is considered to be 101-200 days per year.</td></tr>
<tr><td>Justification for intensity of fishing</td><td colspan="5">Detectable evidence of nephrops trawling occurs reasonably often and on a broad spatial scale that overlaps with the distribution of burrowed mud habitat, where the target species is solely found. The intensity of the interaction is therefore deemed to be major.</td></tr>
<tr><td>Justification for consequence score</td><td colspan="5">Scientific evidence indicates that post trawling events there is a 6% reduction in community biomass and abundance (Hiddink et al. 2017), and 9% reduction in species richness (Sciberras et al., 2018). Recovery times range from 10 days to 1.9-6.4 years post trawling (Sciberras et al., 2018, Hiddink et al. 2017).

Overall, the expert group consider the consequence of the fishery interactions with the ecosystem likely to cause up to 10% change in the sub-component characteristic, with the impact likely to take up to 20 years to recover. This is supported by scientific research. This meets the SG60 SICA requirement. The SG80 and SG100 are not met</td></tr>
</table>

5. Recommendations

5.1.1 This SICA report brings together a range of views provided by an expert group, facilitated through an interactive workshop.

5.1.2 The ecosystem has been defined as the mud habitat fished by TR1 and TR2 trawling gear when targeting nephrops in:

- Western region (including West of Scotland and Irish Sea)
- Greater North Sea

5.1.3 Overall, the SICA for ecosystem outcome status (2.5.1) meets SG60 requirements for TR1 and TR2 trawl gear targeting nephrops in the Western region and Greater North Sea.

5.1.4 The findings of this SICA align with the scoring assessment of the nephrops pre-assessment (Poseidon, 2019).

5.1.5 While it is recognised that assessments are based on the best available data at the time of analysis, it is recommended that this SICA is reviewed when fishing spatial data becomes available for vessels <12m in length.

5.1.6 Based on the fishing gear interaction with the habitat being most likely to cause effect on the ecosystem, it is recommended that ecosystem management is aligned with habitat management measures being reviewed and developed within the Action Plan.

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Appendix A: List of SICA workshop participants

Attendees	Organisation
Annika Clements	Ulster Wildlife Trust
Bill Lart	Seafish
Calum Duncan	Scottish Environment Link
Chris McGonigle	Ulster University
Claire Pescod	Macduff Shellfish
Ewen Bell	Centre for Environment, Fisheries and Aquaculture Science
Fiona Nimmo	Poseidon Aquatic Resource Management Ltd
Hayley Swanlund	WWF-UK
Jan Geert Hiddink	Bangor University
Jo Pollett	Marine Stewardship Council
Matthew Spencer	Marine Stewardship Council
Kenny Coull	Scottish White Fish Producers Association
Mike Park	Scottish White Fish Producers Association

Appendix B: MSC Ecosystem Component

MSC default assessment tree for Ecosystem Outcome Status (2.5.1)

Component	PI	Scoring issues	SG60	SG80	SG100
Ecosystem	Outcome Status **2.5.1** The UoA does not cause serious or irreversible harm to the key elements of ecosystem structure and function.	(a) Ecosystem status	**The UoA is unlikely** to disrupt the key elements underlying ecosystem structure and function to a point where there would be a serious or irreversible harm.	**The UoA is highly unlikely** to disrupt the key elements underlying ecosystem structure and function to a point where there would be a serious or irreversible harm.	**There is evidence** that the UoA is highly unlikely to disrupt the key elements underlying ecosystem structure and function to a point where there would be a serious or irreversible harm.

Definitions

Ecosystem	Broader ecosystem elements such as trophic structure and function, community composition, and biological diversity.
Highly unlikely	Probability requirement for highly unlikely = less than the 30th percentile. i.e. there is less than a 30% probability that the UoA disrupts key elements of the ecosystem. {unlikely = <40th %ile. Highly unlikely = <30th %ile. Evidence = <20th %ile}
Key elements	Key ecosystem elements are the features of an ecosystem considered as being most crucial to giving the ecosystem its characteristic nature and dynamics, and are considered relative to the scale and intensity of the UoA. They are features most crucial to maintaining the integrity of its structure and functions and the key determinants of the ecosystem resilience and productivity.
Serious of irreversible harm	Serious or irreversible harm to "structure or function" means changes caused by the UoA that fundamentally alter the capacity of the ecosystem to maintain its structure and function. This could be the reduction of key features most crucial to maintaining the integrity of the ecosystem structure and functions and ensuring that ecosystem resilience and productivity is not adversely impacted. This includes, but is not limited to, permanent changes in the biological diversity of the ecological community and the ecosystem's capacity to deliver ecosystem services.

Scale intensity consequence analysis (SICA)

The 2.5.1 PI is scored via risk based framework (RBF) where information is not available to support an analysis of the impact of the fishery on the ecosystem.

However, the team may consider using the SICA to assess this PI in the default assessment tree as a means of obtaining the range of viewpoints and constructing the probability interpretation of the scoring guideposts.
The overall SICA scoring template is provided in the table below.
The stakeholder questionnaire tab is intended to provide information for this table to be completed.

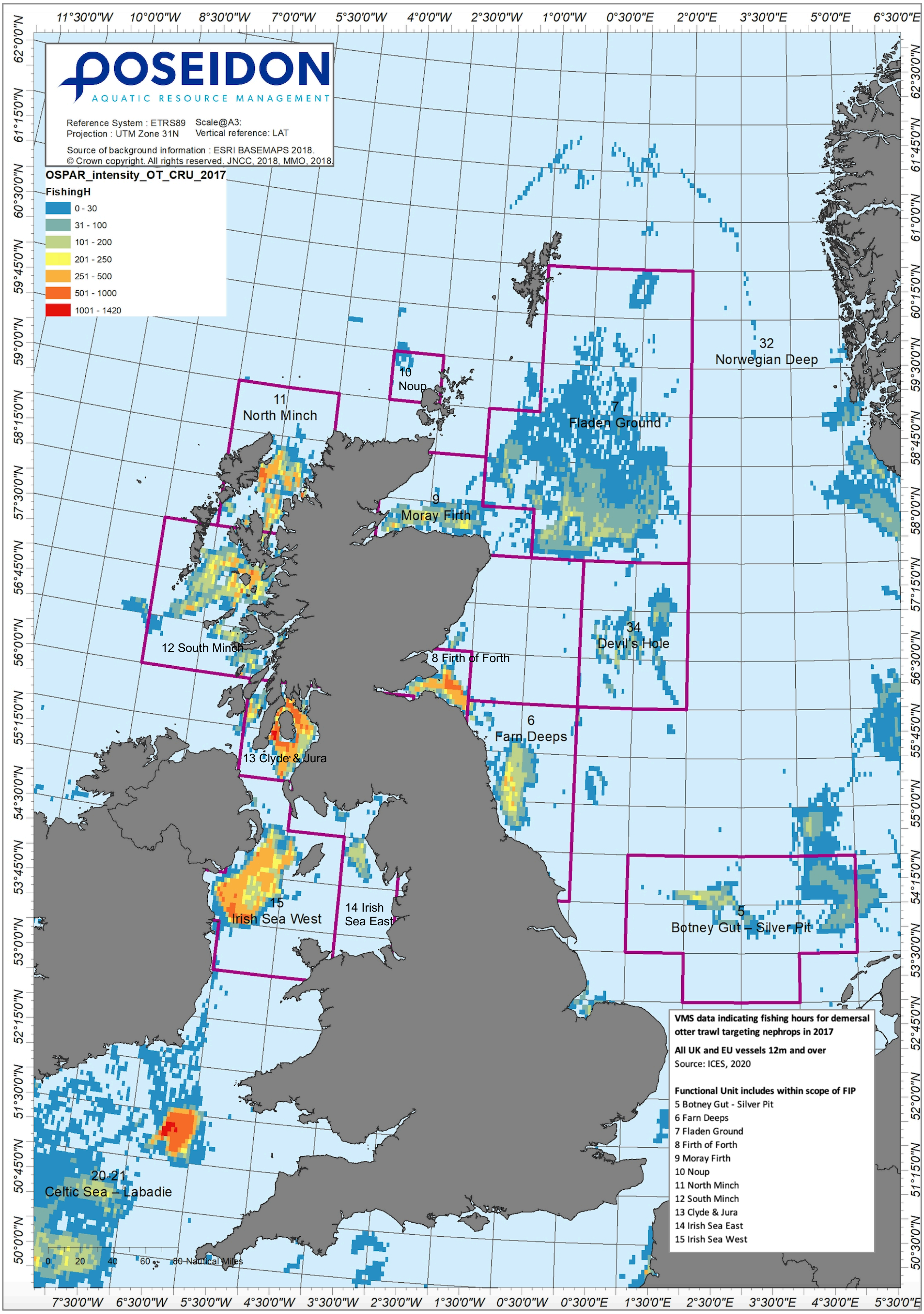
Performance indicator PI 2.5.1 Ecosystem	Spatial scale of fishing activity	Temporal scale of fishing activity	Intensity of fishing activity	Relevant subcomponents	Consequence score
Fishery name	scores 1, 2, 3, 4, 5 or 6	scores 1, 2, 3, 4, 5 or 6	scores 1, 2, 3, 4, 5 or 6	Species composition	scores 60, 80 or 100
				Functional group composition	scores 60, 80 or 100
				Distribution of the community	scores 60, 80 or 100
				Trophic size/structure	scores 60, 80 or 100
Justification for spatial scale of					
Justification for temporal scale of					
Justification for intensity of fishing					
Justification for consequence					

Appendix C: Stakeholder Questionnaire

Question			Answers			
Q.1	**Define the geographic area of the ecosystem(s) and specify reason**					
	a	One overall ecosystem for all waters targeted by the fishery				
	b	Three ecosystems: North Sea, West of Scotland and Irish Sea				
	c	More than three ecosystems: please specify				
Q.2	**What elements of the ecosystem do you think may be affected by the fishery?** Please rank elements 1 to 5, where 1 is most affected and 5 is least affected. Please enter answers in one column OR many columns where your answer varies across different ecosystems.		One overall ecosystem	North Sea	West of Scotland	Irish Sea
	a	Composition of the species in the ecosystem				
	b	Functional group (for example, plankton)				
	c	Distribution of communities				
	d	Trophic structure				
	e	Size structure				
	f	Other element of the ecosystem (specify)				
Q.3	**Which element of the ecosystem do you think is most likely to be affected by the fishery?** Please choose one option - this is likely to align with the element ranked as 1 in Q.2. Please enter answers in one column OR many columns where your answer varies across different ecosystems.		One overall ecosystem	North Sea	West of Scotland	Irish Sea
	a	Composition of the species in the ecosystem				
	b	Functional group (for example, plankton)				
	c	Distribution of communities				
	d	Trophic structure				
	e	Size structure				
	f	Other element of the ecosystem (specify)				
	Please explain the basis for your choice.					
Q.4	**What aspect of fishing activity is most likely to affect the ecosystem?** By please choose one option. Please enter answers in one column OR many columns where your answer varies across different ecosystems.		One overall ecosystem	North Sea	West of Scotland	Irish Sea
	a	Fish removal (i.e. removal of the target species and/or other species caught by the fishery)				
	b	Interaction with the habitat				
	c	Loss of fishing gear				
	d	Bait collection (if relevant to the fishing industry)				
	e	Anchoring gear (if relevant for fishing)				
	f	Boat mooring (if relevant for fishing)				
	g	Other fishing activity (please specify)				
	Please explain the basis for your choice.					
Q.5	**Spatial scale: what is the scale of overlap between the fishery and the element of the ecosystem that is most likely to be affected by it?** Please select one option based on your expert judgement. Please enter answers in one column OR many columns where your answer varies across different ecosystems.		One overall ecosystem	North Sea	West of Scotland	Irish Sea
	a	Less than 1% overlap				
	b	1-15% overlap				
	c	16-30% overlap				
	d	31-45% overlap				
	e	46-60% overlap				
	f	Over 60% overlap				
	Please explain the basis for your choice.					

Question			Answers			
Q.6	**Time scale: how often does the fishery interact with the element of the ecosystem that is most likely to be affected by it?** Please select one option based on your expert judgement. Please enter answers in one column OR many columns where your answer varies across different ecosystems.		One overall ecosystem	North Sea	West of Scotland	Irish Sea
	a	1 day every 10 years or so				
	b	1 day every few years				
	c	1-100 days per year				
	d	101-200 days per year				
	e	201-300 days per year				
	f	301-365 days per year				
	Please explain the basis for your choice.					
Q.7	**Intensity: How intense is the interaction of the fishing industry with the element of ecosystem that is most likely to be affected by it?** This relates to the element identified in Q.3. Please select one option based on your expert judgement. Please enter answers in one column OR many columns where your answer varies across different ecosystems.		One overall ecosystem	North Sea	West of Scotland	Irish Sea
	a	Remote probability of the effect of the activity detected at any spatial scale or temporary (negligible)				
	b	Activity occurs rarely or in some restricted places, and evidence of activity even at these scales it is rare (minor)				
	c	Moderate activity detection on a wider spatial scale or obvious detection but local (moderate)				
	d	The detectable evidence of activity occurs reasonably often on a broad spatial scale (major)				
	e	Easily detectable localized evidence of activity and widespread and frequent evidence of activity (severe)				
	f	Local or regional evidence of activity or continuous and widespread evidence (catastrophic)				
	Please explain the basis for your choice.					
Q.8	**Consequence: what do you think are the consequences of the impact of the fishery on the aspect of the ecosystem most likely to be affected?** This relates to the element identified in Q.3. Please select one option based on your expert judgement. Please enter answers in one column OR many columns where your answer varies across different ecosystems. Please see **Annex A** for further guidance on justifications relevant for each option.		One overall ecosystem	North Sea	West of Scotland	Irish Sea
	a	Interactions are unlikely to be detectable against natural variation.				
	b	Interactions are likely to cause up to 5% change in characteristic; impact recovery is likely to take up to 5 years.				
	c	Interactions are likely to cause up to 10% change in characteristic; impact recovery is likely to take up to 20 years.				
	Please explain the basis for your choice.					
Q.9	**Other comments: Do you have any other comments on this evaluation of the fishery?**					
Q.10	**Other references: Do you have any other sources of info / references relevant to this fishery?**					

Appendix D: VMS Data



Guidance for assessing consequence category for each ecosystem subcomponent

Subcomponent	Fail	60	80	100
Species composition	Consequence is higher risk than 60 level.	Detectable changes to the community species composition without a major change in function (no loss of function). Changes to species composition up to 10%. Time to recover from impact on the scale of several to 20 years.	Impacted species do not play a keystone role (including trophic cascade impact) – only minor changes in relative abundance of other constituents. Changes of species composition up to 5%. Time to recover from impact up to 5 years.	Interactions may be occurring that affect the internal dynamics of communities, leading to change in species composition not detectable against natural variation.
Functional group composition		Changes in relative abundance of community constituents up to 10% chance of flipping to an alternate state/ trophic cascade.	Minor changes in relative abundance of community constituents up to 5%.	Interactions that affect the internal dynamics of communities leading to change in functional group composition not detectable against natural variation.
Distribution of the community		Detectable change in geographic range of communities with some impact on community dynamics. Change in geographic range up to 10% of original. Time to recover from impact on the scale of several to twenty years.	Possible detectable change in geographic range of communities but minimal impact on community dynamics change in geographic range up to 5% of original.	Interactions that affect the distribution of communities unlikely to be detectable against natural variation.
Trophic/size structure		Changes in mean trophic level and biomass/number in each size class up to 10%. Time to recover from impact on the scale of several to 20 years.	Change in mean trophic level and biomass/number in each size class up to 5%.	Changes that affect the internal dynamics unlikely to be detectable against natural variation.

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