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Scientific, Technical and Economic Committee for Fisheries (STECF) - Technical Measures in the Celtic Sea (STECF-21-18)

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Abstract

Commission Decision of 25 February 2016 setting up a Scientific, Technical and Economic Committee for Fisheries, C(2016) 1084, OJ C 74, 26.2.2016, p. 4–10. The Commission may consult the group on any matter relating to marine and fisheries biology, fishing gear technology, fisheries economics, fisheries governance, ecosystem effects of fisheries, aquaculture or similar disciplines.

This report synthesises the findings of the EWG-21-18 that was tasked to increase the knowledge of the current situation regarding protecting cod and whiting stocks in the Celtic Sea. EWG 21-18 has conducted a suite of analyses related to the development of technical measures (TM) for fisheries in the Celtic Sea, first of all basing these analyses on a new and updated dataset of commercial fisheries data that the North Western Waters (NWW) EU Member states (MS) group. This dataset was collated answering the implementation of an official data call, data collated via respective MS scientific data representatives and ahead of the meeting to make the commercial fisheries-related data available to the present EWG 21-18. In addition to this commercial dataset, EWG 21-18 complemented with fisheries-independent data and identified the main fleet segments contributing to the fishing mortality of cod and whiting using the latest ICES assessment coupled to the STECF FDI database (2015-2019), including the estimation of unwanted catch. Finally, EWG 21-18 analysed the ICES trawl survey DATRAS database (2009-2020) to deduce persistent hotspot areas of the cod and whiting distribution that would constitute the basis for designating candidate ICES rectangles and months to close. EWG 21-18 findings show that:

1) the bottom otter trawl fleets using larger mesh-size (100-119mm) have the highest partial Fs for cod and haddock, while fleets using smaller mesh-size (70-99mm) contribute more to F for whiting;

2) thousands of trips and hundreds of vessels are impacted by the current regulation requiring the use of the raised fishing line gear for trips exceeding 20% of haddock in catch composition as per article 13 of Regulation (EU) 2020/123 and article 15 of Regulation (EU) 2021/92, and show that the most appropriate species for setting a catch threshold is indeed haddock in terms of catches of cod in tonnes covered and the minimised impact on historical revenue;

3) The existing closed areas contained in Annex VI Part C paragraph 2 of Regulation (EU) 2019/1241 (the so-called Trevose closures) do not appear to protect areas of highest densities of cod and whiting;

4) a decrease in short term revenue per unit of effort, associated with a reduction in cod catches from closing some ICES rectangles for some periods, if optimised to minimise the effect on revenue, would decrease more slowly than catch reduction with a larger fraction of closed areas. This reduction in potential revenue would, however be larger when protecting cod than for other species, and the effect would be specific to fleets;

5) implementing the raised fishing line gear would have the same order of magnitude or a higher short-term impact than the one caused by the fisheries being choked (assuming effective implementation of the landing obligation);

6) the measures recently introduced by the UK are likely to lead to relatively minor adjustments to exploitation patterns compared to the EU measures. However, these measures do reduce the flexibility afforded in the EU legislation in terms of the gear options fishers can use in certain fisheries.

SCIENTIFIC, TECHNICAL AND ECONOMIC COMMITTEE FOR FISHERIES (STECF) - Technical Measures in the Celtic Sea (STECF-21-18)

Background provided by the Commission

Celtic Sea cod and whiting are target stocks regulated under the Western Waters Multi-annual plan (WWMAP). Since 2019, when ICES' catch advice showed that cod and whiting stocks in the Celtic Sea are below Blim, only bycatches are allowed for both stocks. As such, and in line with Article 8 of the WWMAP, the Union was legally obliged to adopt remedial technical measures as safeguards, to help rebuild these stocks.

Specific remedial measures were for the first time adopted under Regulation (EU) 2020/123. The measures for cod aimed at improving selectivity by making mandatory the usage of a suit of gears that have lower levels of by-catches of cod in the areas where cod catches are significant, thus decreasing the fishing mortality of that stock in mixed fisheries.

Later in 2020, and for implementation in 2021, the Fisheries Council of December 2020 adopted the "Remedial measures for cod and whiting in the Celtic Sea" under article 15 of the 2021 Fishing Opportunities regulation (EU) 2021/92. These measures aim at continuing the implementation of the measures introduced in 2020, hence to reduce bycatches of gadoids in TACs of species caught in mixed fisheries together with gadoids (e.g. haddock, megrims, anglerfish and Norway lobster), as, without those measures in place, TAC levels of target species should be reduced to ensure that gadoid stocks are able to recover.

Simultaneous to the adoption of these measures, Member States have been carrying out some additional selectivity studies, and France has assessed the biological and socio-economic impact of the raised fishing line and other technical measures in the Celtic Sea but only for French vessels. This was assessed by STECF in March 2020 who concluded that this analysis ideally should be re-run with data from other Member States to ascertain the wider impacts and benefits of the those technical measures (STECF PLEN 20-01).

In the sequence of the above, the North Western Water Member Sates Group have identified the need of increasing the knowledge of the performance of the technical measures for all fleets operating in the Celtic Sea and the benefit of an evaluation of the technical measures adopted in Celtic Sea and emphasizing on the requirement for a bio-economic impact assessment. For that, the NWW MS Group has developed the objectives of the study and launched a data call to collate the necessary data that will underpin the study.

The Commission has positively responded to this request raised by the NWW MS Group, and after that consulted STECF that have also agreed that the work envisaged is comprehensive and warrants dedicating an Expert Working Group to carry out the analysis.

In addition, in June 2021, the UK has notified DG MARE of their intention to introduce new technical measures into the Celtic Sea from the 5th September 2021. These measures will apply in UK waters and differ quite significantly to the current EU measures in place in the Celtic Sea.

With the background of the details provided above, the follow terms of reference have been compiled and are addressed to the STECF.

Terms of Reference for EWG-21-18

Based on the dataset provided by the North-Western Waters MS Group, and the accompanying results prepared by the MS Group; having in mind the objectives of the study as set by the NWW MS Group for an analysis on the remedial technical measures in the Celtic Sea; and lastly, taking into account the STECF PLEN 21-02 advice, notably on guidance and methods to be followed in carrying out these analysis, **EWG 21-18 was requested to**:

ToR 1. As regarding the fleets operating in the Celtic Sea

i) Estimate the contribution of all fleets operating in the Celtic sea to the fishing mortality of all exploited species and in particular F for cod, haddock and whiting.

ii) Evaluation of the conditions of application of specific technical measures trigger by thresholds according to a suit of different catch thresholds (the ones currently implemented by the Union, by the UK, and any other threshold level relevant to be further investigated).

ToR 2. As regarding seasonal closures of relevant parts of the Celtic Sea Protection Zone

i) Evaluate the efficiency of existing closed area for the conservation of cod in ICES divisions 7f and 7g (Regulation (EU) 2019/1241). The analysis should include the efficiency in protecting spawners and juveniles of cod and the economic impact of the closure.

ii) Explore alternative closures in duration, season and/or geography when (if) the current closure is no longer effective. In doing so, the possible displacement of fishing effort to other areas and/or fisheries should be taken into account in the design of new closures.

ToR 3. Conduct a bio-economic impact assessment of adopted technical measures, specifically raised-fishing line, and alternative technical measures. The bio-economic model should integrate all exploited species and all fleets operating in the Celtic Sea and take into account the uncertainty. The technical measures should be evaluated with a simulation study to ensure that they meet the sustainability of the resources (cod, whiting, and all possible target species) and in terms of economic objectives.

ToR 4. Evaluate, to the extent possible, the potential effectiveness of the measures to be introduced by the UK from the 5th September 2021 on cod and whiting stocks in the Celtic Sea in comparison to the current measures in EU waters. Comment on any issues that the differences in measures create.

Request to the STECF:

STECF is requested to review the report of the STECF Expert Working Group meeting, evaluate the findings and make any appropriate comments and recommendations.

STECF comments

EWG 21-18 met online from the 1st to the 5th of November 2021. The meeting was attended by 13 experts in total, including three STECF members and one JRC staff. One DG MARE representative and six observers (from France, Ireland, Spain and Belgium) also attended the meeting.

STECF observes that the EWG used three data sources to respond to the ToRs: 1) a new and updated dataset of commercial fisheries data that the North-Western Waters (NWW) EU Member States (MS) group collated for 2017-2019 (2020 incomplete), 2) the STECF FDI database 2015-2019 (https://stecf.jrc.ec.europa.eu/dd/fdi) and 3) information from the French EVHOE and Irish IE-GFS surveys from DATRAS database 2009-2020 (https://datras.ices.dk/Data_products/Download/Download_ Data_public.aspx) for ICES stocks cod27.7e-k, whg.27.7b–ce–k, and had 27.7a. The EWG used the approach developed by STECF PLEN-20-01 but extended it to apply the analysis to the Spanish, French, Irish and Belgian commercial data.

STECF notes that all the ToRs were addressed by the EWG, with ToR 3 subdivided in two parts.

STECF notes the following main findings of the EWG by TOR:

ToR 1.1

The bottom otter trawl fleets using larger mesh-size (100-119mm) have the highest partial fishing mortality "F" for cod and haddock, while fleets using smaller mesh-size (70-99mm) contribute more to "F" for whiting. The fishing mortality over the 2015-2019 period peaked in 2017-2018 for cod, 2016 for whiting, and 2017 for haddock. By far, the highest partial F for cod was observed in ICES division 27.7g while the highest fishing mortality for whiting was mostly in 27.7g and 27.7e (e.g. French and UK coastal areas). Fishing mortality for haddock was spread over 27.7e, g, h and a lesser extent in 27.7j.

ToR 1.2

STECF observes that the results from EWG 21-18 showed that there could have been 1805 trips out of 14533 cumulated trips over 2017-2019 potentially impacted by the current 2021 Regulation requiring the use of the raised fishing line gear for trips exceeding 20% of haddock in catch composition (as per article 13 of Regulation (EU) 2020/123 and article 15 of Regulation (EU) 2021/92). This number of impacted trips exceeding 20% of haddock is equivalent or slightly less than the number of trips impacted if a 20% threshold would apply not to haddock but individually to other commercially important species such as megrim, hake, whiting and especially *Nephrops*. More trips would be impacted if this % threshold on haddock was set at a lower level, (i.e. including other trips not targeting haddock only). With the current 20% haddock threshold, the Regulation would only have impacted France and Ireland, with 1038 trips out of 4152 trips of 80 vessels for France and 767 trips out of 9714 trips of 128 vessels for Ireland in 2017-2019.

The EWG 21-18 static catch threshold analysis also showed that the most appropriate species for setting a catch threshold is indeed haddock, both in terms of catches of cod in tonnes potentially avoided and in terms of negative impact on revenues. The >20% haddock threshold specified in the current Regulation would have impacted fewer trips and vessels while still outperforming the potential thresholds on any other species in terms of potential reduction in cod catches. Compared with the current 20% haddock threshold, a 10% additional increase (>30% haddock threshold) would imply a reduction of the number of trips impacted and of avoided cod catches by 53% and 59%, respectively. On the other hand, with a 10% decrease (>10% haddock threshold) the cod catches would increase by a factor 2.6 and the number of trips impacted by 2.3. In addition, for the equivalent saved cod tonnes, the 20% haddock threshold would have affected less of the trips revenues than a threshold applied on other species.

ToR 2.1

The existing closed areas contained in Annex VI Part C paragraph 2 of Regulation (EU) 2019/1241 (the so-called Trevose closures) do not appear to protect areas with the highest density of cod throughout the year. This is indicated by the survey occurring in year Q4 and by the commercial catches observed during the year. However, a persistent hotspot area (identified over several years) for whiting, and eventually haddock, seems to have occured within the ICES rectangles of the Trevose closure over 2009-2020.

STECF notes that the EWG 21-18 was not able to evaluate the historical efficiency and economic impacts of the Trevose closure because relevant data is not available. The scientific surveys only take place in Q4 while the area is closed during Q1 (February and March) and the commercial data available to the EWG did not include the early years of the closure, which was established in 2005.

ToR 2.2.

EWG 21-18 investigated optimal combinations of ICES rectangles and periods that would provide the highest protection for cod while minimising the effect on short-term revenues. This analysis showed that the fraction of economic returns impacted by a potential catch reduction would increase as expected along with a larger fraction of closed areas. Yet the cod catch would comparatively reduce more. Hence, a 40% cod catch reduction would only imply a 20% reduction in short-term revenue per unit of effort. However, it is anticipated in the report that this decrease in revenue per species per unit of effort, associated with a reduction in cod catches, would be larger for cod than for other species, (i.e. haddock and whiting), primarily because cod catches are associated with areas and fisheries with higher economic returns.

STECF observes that convergent information identified by the EWG supports that substantial catch reductions of cod could be achieved by closing several ICES statistical rectangles off the South Coast of Ireland (Rectangles 31E1, 31E2, 30E0, 30E1, 32E1). These areas should be closed seasonally from the northeast to the south-west following changing cod distribution over the year. However, STECF observes that all the identified closed areas and periods would imply a significant reduction in revenues, and impact some fleets more specifically. This is directly related to changes in the catch opportunities of the relevant fleets. In this regard, STECF notes that until 2019 (with data 2017-2019 being analysed) there seemed to be a high economic dependency of the fisheries on cod. STECF notes though that this is unlikely to be the case since 2020 considering that only bycatch quotas have been allocated, with no directed fishing for cod permitted and remedial technical measures put in place. These measures are designed to avoid closing cod fisheries prematurely.

STECF notes that the report illustrates that effort displacement could potentially reduce the effectiveness of the proposed closures to reduce catches of cod and whiting significantly. This is particularly the case for cod, where the closures were focused on the Celtic Sea Protection Zone (CSPZ) defined in the Regulation. In this area, fleets would have the ability to allocate fishing effort to the less restricted areas outside the CSPZ. This would potentially reduce the effect of the closures substantially (e.g. where a 60% reduction in cod catches inside the CSPZ would be reduced to 20% in total). On the other hand, the economic returns from displacement may be overestimated as catch rates for the targeted species in the Celtic Sea would most likely decrease in other areas (lower CPUE) if the same fishing effort was concentrated in a smaller area.

STECF notes therefore, that considering the high importance of cod even as a bycatch species, any closure proposal should be accompanied by a reduction in fishing effort overall to effectively reduce unwanted (by)catches, prevent unintended effort displacement and limit inducing increased operating costs and lower economic returns.

ToR 3.1.

STECF observes that EWG 21-18 was only able to conduct a static bio-economic analysis, based on the same approach as used in PLEN 20-01. The results indicated that the implementation of the 'raised fishing line' selectivity device on trawls in the Celtic Sea Protection Zone has a potentially negative short-term economic impact. This impact is estimated higher than an alternative scenario where the fisheries would close following choke species issues (assuming effective implementation of the landing obligation) for the French, Irish and Belgian trawl fleets. In the case of the Spanish fleets, STECF notes that the interpretation of the results of this comparative analysis are less clear since they only catch very limited amounts of cod and haddock.

STECF observes that this assessment of economic impacts, although limited to short-term change in revenue only, still gives useful indications on which combination of reduced cod catches may lead to comparably low reductions in catch of other species.

STECF stresses, however, that the results of the static bio-economic analyses should be interpreted with caution as they do not include mixed fisheries considerations, and do not consider the reallocation of fishing effort or other possible selectivity devices which would reduce cod catches. It is also uncertain whether the calculated losses in revenue would be problematic for the fishing fleets. The EWG was not able to compare the calculated possible losses with economic performance data from the AER for the impacted fleets.

ToR 3.2.

STECF observes that a dynamic bio-economic assessment is considered the better approach to conducting an impact assessment of technical measures. For this purpose, the EWG investigated options to use the fleet-based FLBEIA model, which is being developed for the Celtic Sea in various research projects and by ICES working groups. However, the EWG concluded that the current state of development of this model did not allow exploring management strategies as those discussed by the EWG at this time. More work is required before a fully operational model with appropriate fleet datasets is available. In addition, the FLBEIA model is not spatially-disaggregated, and cannot easily evaluate scenarios of spatial closures, effort displacement or changes in species distribution due to e.g. climate change. STECF notes that an alternative spatially-explicit DISPLACE model was presented to the EWG, which could be investigated and developed further to explore alternative spatial scenarios. STECF further notes that operating several alternative models with different characteristics and capabilities can be a useful combination to explore a wide range of management options, similarly to what has been carried out in STECF EWGs dealing with the Western Mediterranean management plan (STECF 21-13).

ToR 4.

STECF observes that the measures introduced by the UK are likely to lead to relatively minor adjustments to exploitation patterns compared to the EU measures. The default gear selected by the UK, with a mesh size of 110 mm and 120 mm square mesh panel, is the most selective of the gear options included under the EU legislation (i.e. Technical Measures Regulation 2019/1241 Annex VI). The different *Nephrops* catch threshold, and the prohibition on strengthening bags may have no negative or marginal effect in affecting protection of cod in the Celtic Sea, and therefore on the EU fleet. However, the default 100 mm and 100 mm square mesh panel in ICES divisions 27.7e and 27.7h within UK waters could negatively impact cod catches as the gear has a poorer selectivity with a lower L50 for cod than other gears under EU legislation. On the other hand, the impact of removing the requirement to use the raised fishing line gear is still uncertain. It will impact the selectivity for cod and whiting, but past experience showed that fishers might change the catch species profile to avoid using any alternative device. Finally, the derogation of 80 mm and 120 mm square mesh panels affects a small area where the current abundance of cod and whiting is low.

STECF conclusions

STECF concludes that the EWG 21-18 fully addressed all of the ToRs.

STECF concludes that the approach taken by the EWG is scientifically sound. The data used are the best available and are sufficient to support the methods and findings. However, the outputs from the static approach adopted in TOR 3 are deterministic and hence the precision of the results cannot be fully quantified.

STECF agrees with the conclusion of the EWG for TOR 1 that, based on historical 2017-2019 catch data:

- The trawlers fleets using larger mesh-size (100-119mm) have the highest partial Fs for cod and haddock, while smaller mesh-size (70-99mm) contributes more to whiting.
- the most appropriate species for setting a catch threshold is indeed haddock in terms of cod tons covered and the smallest expected impact on revenue.
- The specific >20% haddock threshold specified in the current Regulation impacts fewer trips and vessels while still outperforming the potential thresholds on any other species.

STECF concludes that for TOR 2,

- closing ICES statistical rectangles off the Central Irish South Coast (31E1, 31E2, 30E0, 30E1, 32E1), with a northeast south-westwards trend throughout the year, would decrease cod catches.
- The potential for effort displacement may though significantly reduce the effectiveness of the CSPZ closures in reducing catches of cod and whiting. Considering the historically high dependency of the fisheries on cod catches, any closure proposal would thud need to be accompanied by a reduction of fishing pressure overall to effectively reduce unwanted (by)catches, prevent unintended effort displacement and limit inducing increased operating costs and lower economic return.

STECF concludes for TOR 3 that:

in terms of short-term losses, and in the absence of any fleet adaptation, the implementation of the 'raised fishing line' selectivity device on trawls in the CSPZ would have the same magnitude of impact as the early closure of the fishery for some fleets, noting this is based on a limited static assessment.

- the application of a dynamic bio-economic model to conduct a medium-term assessment would be beneficial. More work should be dedicated to operationalising current fleet-based FLBEIA model and further exploring the spatially-explicit DISPLACE model.

Finally, in relation to TOR 4 STECF concludes that the measures introduced by the UK are likely to lead to relatively minor adjustments to exploitation patterns compared to the EU measures.

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REPORT TO THE STECF

EXPERT WORKING GROUP ON Technical Measures in the Celtic Sea (EWG-21-18)

Virtual meeting, 1-5 November 2021

1 Background provided by the Commission

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Simultaneous to the adoption of these measures, Member States have been carrying out some additional selectivity studies, and France has assessed the biological and socio-economic impact of the raised fishing line and other technical measures in the Celtic Sea but only for French vessels. This was assessed by STECF in March 2020 who concluded that this analysis ideally should be re-run with data from other Member States to ascertain the wider impacts and benefits of the those technical measures (STECF PLEN 20-01).

In the sequence of the above, the North Western Water Member States Group have identified the need of increasing the knowledge of the performance of the technical measures for all fleets operating in the Celtic Sea and the benefit of an evaluation of the technical measures adopted in Celtic Sea and emphasizing on the requirement for a bio-economic impact assessment. For that, the NWW MS Group has developed the objectives of the study and launched a data call to collate the necessary data that will underpin the study.

The Commission has positively responded to this request raised by the NWW MS Group, and after that consulted STECF that have also agreed that the work envisaged is comprehensive and warrants dedicating an Expert Working Group to carry out the analysis.

In addition, in June 2021, the UK has notified DG MARE of their intention to introduce new technical measures into the Celtic Sea from the 5th September 2021. These measures will apply in UK waters and differ quite significantly to the current EU measures in place in the Celtic Sea.

With the background of the details provided above, the follow terms of reference have been compiled and are addressed to the STECF.

1.1 Terms of Reference for EWG-21-18

Based on the dataset provided by the North Western Waters MS Group, and the accompanying results prepared by the MS Group; having in mind the objectives of the study as set by the NWW MS Group for an analysis on the remedial technical measures in the Celtic Sea; and lastly, taking into account the STECF PLEN 21-02 advice, notably on guidance and methods to be followed in carrying out these analyses, **STECF is requested to**:

ToR 1. As regarding the fleets operating in the Celtic Sea

i) Estimate the contribution of all fleets operating in the Celtic sea to the fishing mortality of all exploited species and in particular F for cod, haddock and whiting.

ii) Evaluation of the conditions of application of specific technical measures trigger by thresholds according to a suit of different catch thresholds (the ones currently implemented by the Union, by the UK, and any other threshold level relevant to be further investigated).

ToR 2. As regarding seasonal closures of relevant parts of the Celtic Sea Protection Zone

i) Evaluate the efficiency of existing closed area for the conservation of cod in ICES divisions 7f and 7g (Regulation (EU) 2019/1241). The analysis should include the efficiency in protecting spawners and juveniles of cod and the economic impact of the closure.

ii) Explore alternative closures in duration, season and/or geography when (if) the current closure is no longer effective. In doing so, the possible displacement of fishing effort to other areas and/or fisheries should be taken into account in the design of new closures.

ToR 3. Conduct a bio-economic impact assessment of adopted technical measures, specifically raised-fishing line, and alternative technical measures. The bio-economic model should integrate all exploited species and all fleets operating in the Celtic Sea and take into account the uncertainty. The technical measures should be evaluated with a simulation study to ensure that they meet the sustainability of the resources (cod, whiting, and all possible target species) and in terms of economic objectives.

ToR 4. Evaluate, to the extent possible, the potential effectiveness of the measures to be introduced by the UK from the 5th September 2021 on cod and whiting stocks in the Celtic Sea in comparison to the current measures in EU waters. Comment on any issues that the differences in measures create.

2 EXECUTIVE SUMMARY

The expert working group (EWG) was held remotely as a video conference from the 1st to the 5th of November 2021. The meeting was attended by 13 experts in total, including three STECF members and one JRC staff. One DG MARE representative and six observers (from France, Ireland, Spain and Belgium) also attended the meeting.

Later in 2020, and for implementation in 2021, the Fisheries Council of December 2020 adopted the "Remedial measures for cod and whiting in the Celtic Sea" under article 15 of the 2021 Fishing Opportunities regulation (EU) 2021/92. These measures aim to continue implementing the measures introduced in 2020, hence reducing bycatches of gadoids in TACs of species caught in mixed fisheries together with gadoids (e.g. haddock, megrims, anglerfish and Norway lobster). Without those measures in place, TAC levels of target species should be reduced to ensure that gadoid stocks can recover.

The objective of the EWG-21-18 was to increase the knowledge of the current situation in the Celtic Sea. EWG 21-18 should conduct a suite of analyses related to the development of technical measures (TM) in the Celtic Sea, first of all basing these analyses on a new and updated dataset of commercial fisheries data that the North Western Waters (NWW) EU Member states (MS) group. This dataset was collated answering the implementation of an official data call, data collated via respective MS scientific data representatives and ahead of the meeting to make the commercial fisheries-related data available to the present EWG 21-18.

In particular, the EWG was tasked to:

1. Identify the main fleets contribution to the bycatch of cod and whiting.
2. Identify the main areas where these bycatch occurred in the most recent period (2017-2019) and if these areas and periods correspond to some persistent hotspot areas of the spatial distribution of cod and whiting in the Celtic Sea, and the Celtic Sea Protection Zone (CSPZ).
3. Define possible alternative closed areas and periods, together with assessing the possible bio-economic impact of such proposals, as well as the short-term economic impact of enforcing new gear selective devices triggered by the TM Regulation, such as the "raised fishing line" that should deploy in the CSPZ for certain activities (i.e. trawls in the CSPZ when haddock exceed 20% of the overall catch composition).
4. Assess the possible impact of new or adapted measures on EU fleets and shared stocks when implemented by the UK to regulate the fisheries within the UK EEZ, which would differ from the EU TM Regulation.

The EWG notes that a similar investigation has been conducted in a previous STECF plenary (STECF PLEN-20-01) and, to a large extent, has reused and extended the method developed there with the new skill set of the experts available to conduct this work.

The EWG findings per ToRs were:

ToR 1.1 The trawlers fleets using larger mesh-size (100-119 mm) have the highest partial Fs for cod and haddock, while those using smaller mesh-size (70-99 mm) contribute more to whiting. These Fs over the 2015-2019 period examined peaked in 2017-2018 for cod, 2016 for whiting, and 2017 for haddock. By far, the highest partial F for cod was observed in the ICES division 27.7.g while the fishing mortality for whiting is mostly in 27.7.g and 27.7.e (e.g. French and UK coastal areas), and is more spread for haddock (27.7.e, g, h and very minor in 27.7.j.

ToR 1.2 This shows that there could have been 1805 trips realized that could have been potentially impacted by the current regulation requesting a raised fishing line for trips exceeding 20% of HAD in catch composition. This is equivalent or slightly less than the number of trips impacted on other commercially important species such as megrims, hake, whiting and especially Nephrops, and less than if this % threshold would be set lower, i.e. incorporating other trips not targeting haddock. The regulation affected France and Ireland, with 1038 trips of 80 vessels for France and 767 trips of 128 concerned vessels for Ireland. The present static catch threshold analysis also concludes that the most appropriate species for setting a catch threshold is indeed haddock in terms of cod tons covered and the minimised impact on historical revenue. The specific >20% HAD and currently specified in the current Regulation impacts fewer trips and vessels while still outperforming the potential thresholds on any other species.

ToR 2.1 The existing closed area does not appear to protect persistent areas for cod when deducing those areas from the survey constantly occurring in year Q4. However, a persistent area for whiting reduction could coincide within the specific ICES rectangles of the Trevose closure for that Q4 and eventually haddock. Due to the limited information available for other seasons in the scientific survey, or before 2017 in the commercial data, it was impossible to evaluate the efficiency and economic impact of such a historical measure.

ToR 2.2 EWG 21-18 searched for optimal combination of ICES rectangles and months when designing a closure to protect cod with reduced catches while minimising the effect on short term revenue. This search showed that the economic return would decrease more slowly along with a larger fraction of closed areas than the amount of unwanted catch (a 40% reduction would imply a 20% reduction in short-term revenue per unit of effort). However, EWG 21-18 anticipates that this decrease in revenue per unit of effort along with a reduction in cod catches to be larger than for other species, i.e. haddock and whiting, primarily because cod catches are associated with areas and fisheries with a higher economic return.

EWG 21-18 identified convergent information that would support catch reductions of cod to be mainly achieved by closing ICES statistical rectangles off the Central Irish South Coast (31E1, 31E2, 30E0, 30E1, 32E1), with a northeast south-westwards trend throughout the year. The EWG 21-18 observes that all the identified closed areas and periods would imply a strong impact in terms of the fraction of the historical revenue affected by the closure and specific to fleets. These are directly related to changing the catch opportunities of the fleets.

The EWG 21-18 illustrated that potentials for effort displacement would greatly reduce the effectiveness of the proposed closures into reducing catches of cod and whiting. Especially for cod, where closures were focused on the CSPZ, fleets would have the ability to allocate fishing effort to the open areas outside the CSPZ, causing that a targeted catch reduction of, for example, 60% would only result in an effective reduction of 20% of the cod catches versus status quo. On the other side, the return on the economy from displacement is likely to be overestimated as long as the hyperstability of catch rates would not apply. Therefore, any closure proposal should probably be accompanied by overall effort reduction plans to reduce unwanted (by)catches and limit inducing increased operating costs and lower economic return.

ToR 3.1 The results from a static bio-economic indicate that the implementation of the 'raised fishing line' selectivity device on trawls in the Celtic Sea Protection Zone has a potentially high negative short-term economic impact. This impact is found still higher than the fishery being choked and activity restricted for the French, Irish and Belgian trawl fleets. In the case of the Spanish fleet, this device would lead to a reduction of revenue lower than impact of the fleet being choked immediately due to the lack of cod quota. These results should be interpreted with caution as the performed static bio-economic analysis does not include mixed fisheries considerations and did not consider the reallocation of fishing effort. However, this coarse comparison shows that in terms of short-term losses in the absence of any fleet adaptation, the implementation of the 'raised fishing line' would have the same magnitude of impact as the early closure of the fishery.

ToR 3.2 A dynamic bio-economic assessment is considered the better approach to conduct an impact assessment of technical measures because accounting for possible stock replenishment. Among the existing software, FLBEIA was identified as one of the most appropriate models to conduct this bio-economic impact assessment within the Celtic Sea. Currently, there is not an available FLBEIA model conditioned for the Celtic Sea. Conditioning and developing a model for the Celtic Sea would require the availability of very specific input data and months of work to condition the model and define the scenarios to be simulated. Experts should also further explore alternative dynamic bio-economic models such as DISPLACE to account for spatial effects, fleet behaviour, and adaptation.

ToR 4 The measures introduced by the UK are likely to lead to relatively minor adjustments to exploitation patterns compared to the EU measures. The default gear that the UK selected is the gear with a mesh size of 110 mm and 120 mm square mesh panel is the most selective of the gear options included under the EU legislation. The different Nephrops catch threshold, and the prohibition on strengthening bags may have no negative or marginal effect. However, the default 100 mm and 100 mm square mesh panel in ICES divisions 27.7e and 27.7h within UK waters could impact cod catches as the gear has a lower L50 for cod than other gears under EU legislation. On the other hand, the impact of removing the requirement to use the raised fishing line gear is still uncertain. It will impact the selectivity for cod and whiting, but fishers likely change the catch species profile to avoid using any alternative device. Finally, the derogation of 80 mm and 120 mm square mesh panels affects a small area where the current abundance of cod and whiting is low.

Spain, France and Ireland carried out several studies that looked at alternative gear options during 2020. All of these trials have been hindered by the lack of cod catches to provide statistically sound results and make it impossible to infer any conclusions on the impact of cod from using these gears.

3 ToR 1. As regarding the fleets operating in the Celtic Sea

Framework

Celtic Sea commercial fisheries fish upon a large number of demersal species. One of the main fisheries is a mixed bottom-trawl fishery targeting Nephrops and different benthic and gadoids species. The species catch composition varies according to the area and the countries involved in the fishing activity. The main demersal species in terms of landings caught in the Celtic Sea are hake, whiting, and haddock, followed by anglerfish and megrim. On the other hand, the relative importance of cod has declined in the last decades. Nephrops is the main crustacean species in the area.

The mixed-fisheries advice for demersal fisheries in divisions 27.7.b–c and 27.7.e–k (ICES, 2020) shows that all demersal fleets catch cod and that cod is the most limiting species in the Celtic Sea.

In 2019, the poor situation of the biomass of cod and whiting stocks in the Celtic Sea triggered the adoption of remedial measures to help recover the stocks. The most recent ICES assessment (ICES, 2021a) indicated that the SSB of cod declined from 5981 t in 2016 to 1036 t in 2019, well below any biomass reference point (Figure 3.1). Simultaneously, the fishing pressure in the years 2016-19 reached the highest levels of the time series available.

In the case of the whiting stock, the SSB also decreased in a period of 4 years, passing from being above the MSY Btrigger (51 135 t > MSY Btrigger (47 963 t)) in 2016 to be below Blim in 2019 (Figure 3.2) (ICES, 2021b).

In 2021, the SSB estimated for both stocks remained below their respective MSY Btrigger and a very low level of biomass.

Some analyses carried out in this EWG 21-18 take the years 2017-19 as a reference period. The results of these analyses should be interpreted considering the current status of cod and whiting stocks, especially with the low levels of their biomass.

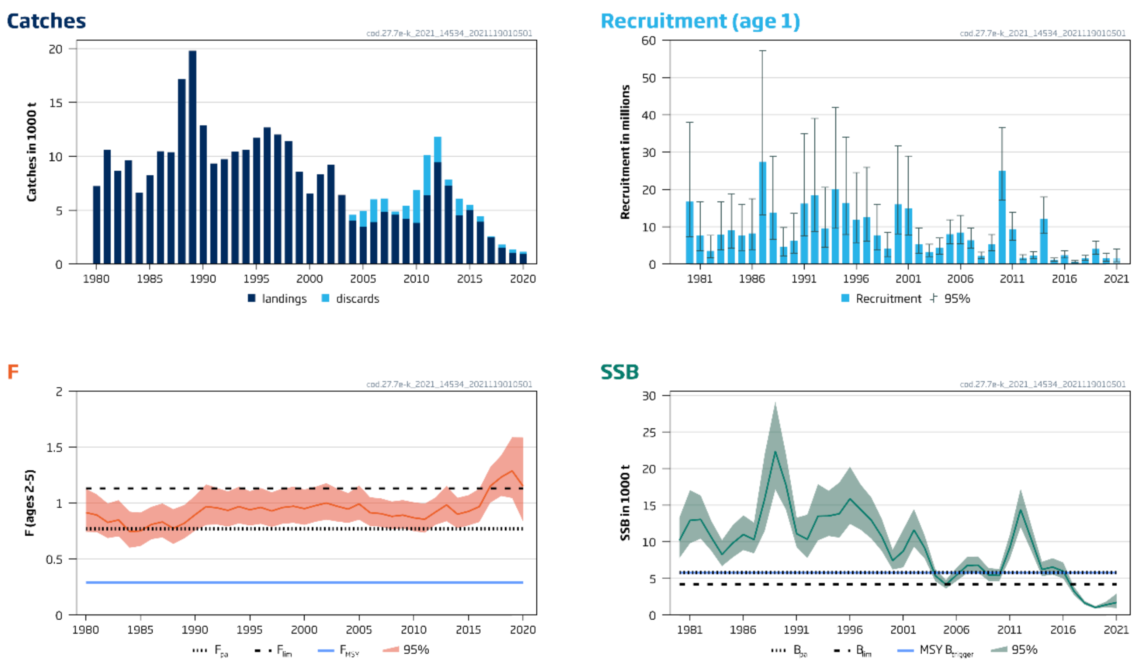

Figure 3.1. Cod in divisions 7.e–k (western English Channel and southern Celtic Seas). Summary of the stock assessment. Recruitment, F and SSB show confidence intervals (95%) in the plot. Figure taken from ICES 2021a.

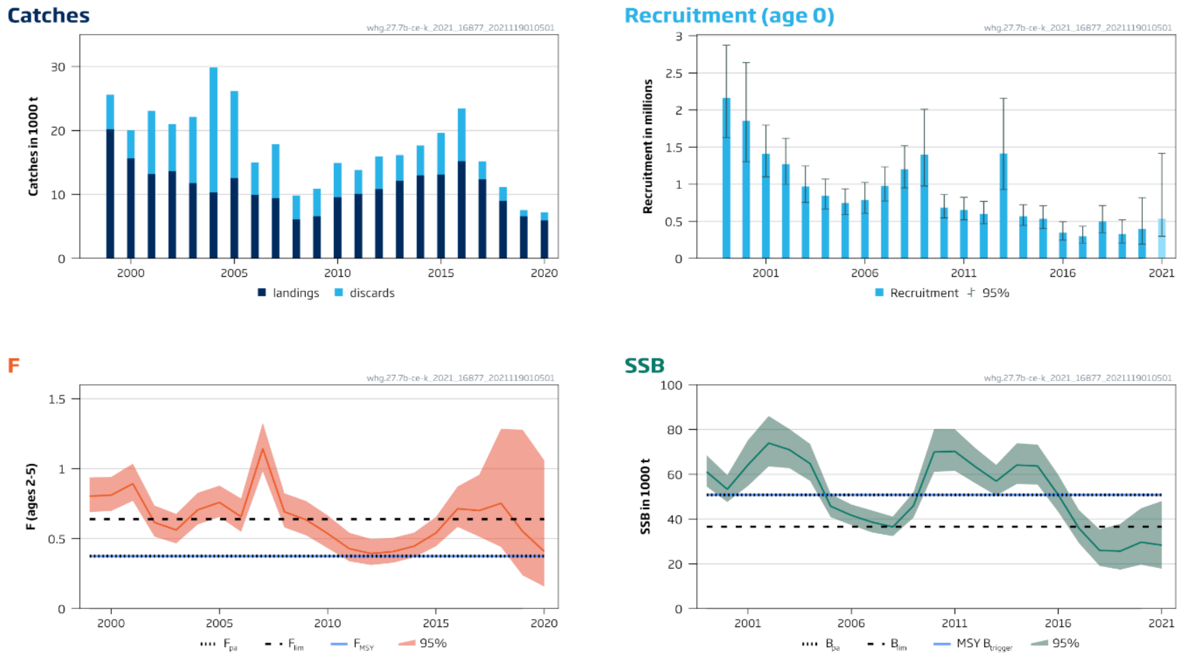

Figure 3.2. Whiting in divisions b-ce–k (western English Channel and southern Celtic Seas). Summary of the stock assessment. Recruitment, F and SSB show confidence intervals (95%) in the plot. Figure taken from ICES 2021b.

3.1 Estimate the contribution of all fleets operating in the Celtic Sea to the fishing mortality of all exploited species and in particular F for cod, haddock and whiting

The estimation of the contribution of all fleets operating in the Celtic Sea to the fishing mortality of the main species was carried out using the catch data from the 'new' FDI database, for 2015-2019, for both EU countries and the UK to give a complete picture of the fishery (i.e. all fleet-segments, unwanted catch included) in the Celtic Sea. The fishing mortality and the biomass for each stock are from the latest assessment (ICES, 2021c).

The fleets were first considered at DCF level 6 métier (gear x target species assemblage x mesh size). Given the important heterogeneity within a given métier between country and fishing area, a more detailed analysis per country and ICES subdivision was also carried out.

This heterogeneity is illustrated by the following (Figures 3.3-3.4):

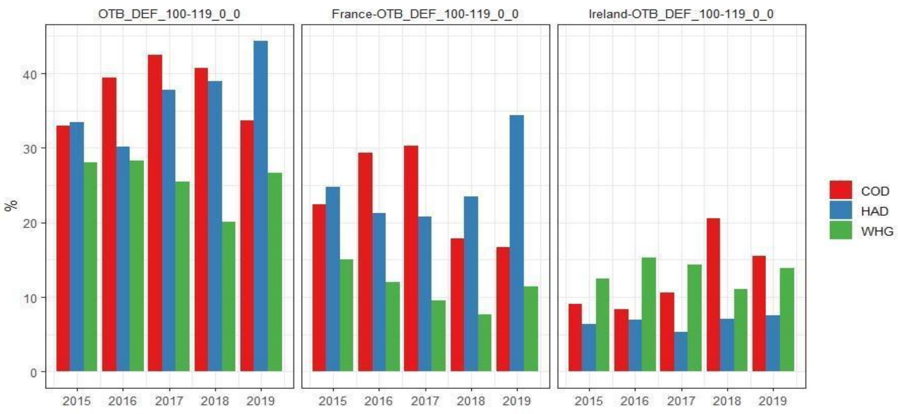

Figure 3.3. Percent contribution to the total catch of the stock for the main contributor segment (OTB_100-119_0_0) and for France and Ireland.

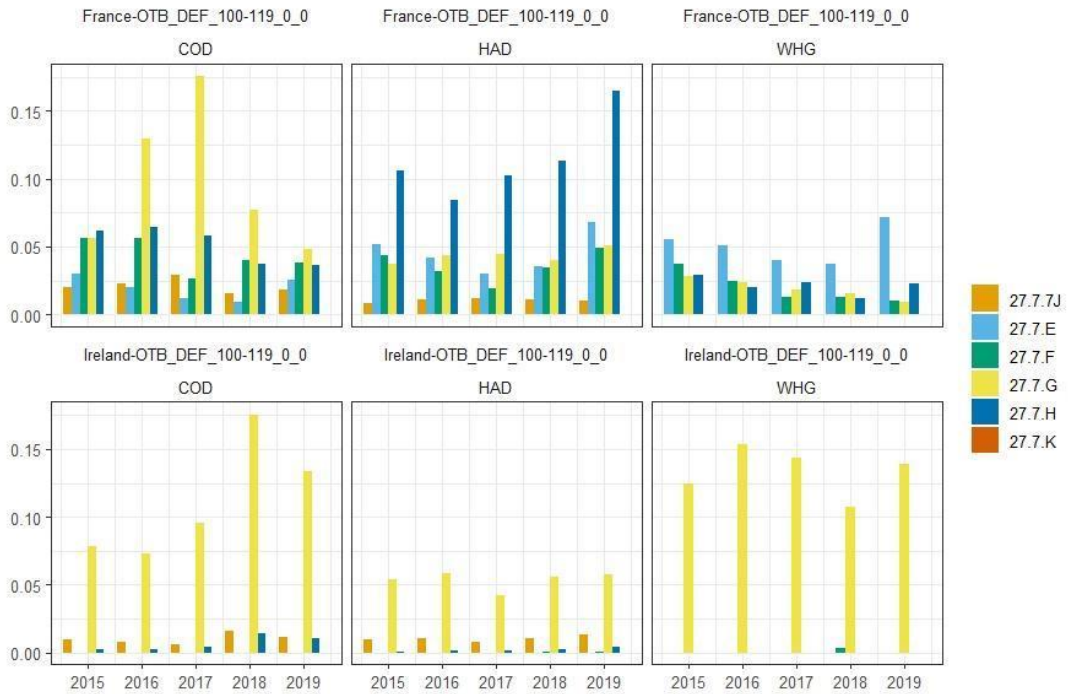

Figure 3.4. Percent of contribution to the total catch of the stock by country-métier, and area for the main contributor segment (OTB_100-119_0_0).

While the métier OTB_DEF_100-119 appears to contribute rather equally to the total catch of the three species of gadoids, the more concerned countries (France and Ireland) do not show the same contribution to species catch (Figure 3.3), and this is more visible when looking at the catches by sub-divisions and over the years (Figure 3.4) where it is shown that the main catch of the Irish fleet consistently occurred in 27.7.g, compared to the catch of the French fleet that occurred in other areas as well, but with less cod in most recent years.

Methods to compute the partial Fs and the Harvest rates

The total catch for each relevant stock (i.e. at the stock level) is first computed to override any discrepancy in the total amount of catches given by FDI and the ones used in ICES, and this total is used to calculate the relative contribution of each country, métier, sub-division (in the Celtic Sea) to the total catch of the stock. This relative contribution is then used to estimate the partial fishing mortalities (Fs). Harvest rates that report the importance of catches this time in depleting biomass (and not in the number of individuals as an F) are also calculated. It was judged that harvest rates could be a valuable complement to account for the total biomass of the stocks and therefore account for the younger fish ages, which are by nature not well-captured into the average Fbar calculated over recruited-to-fishing fish ages. It should be noted that the harvest rate is computed as the straight ratio between the catch by métier, and the total biomass (or spawning biomass for megrim) from the ICES assessment data.

Further disaggregation of F among fishing areas uses the contribution of the area to the catch of the stock:

partial Fmet,zon,stock = Catchmet,zon,stock / Catchstock x Fstock

This procedure for disaggregation may be questionable since it assumes an underlying homogeneous distribution of the fish available to fishing. However, due to the high seasonably effect on the distribution of the main species (e.g. cod), it has been considered that assuming a partition based on an estimate of the biomass among areas based on surveys that take place in one season only (i.e. Autumn) might not be relevant enough. In any case, accurate partial Fs (by area, quarter) should be obtained directly from spatial/seasonal assessment models. In the absence of those, the partial Fs provided in this report are considered proxies to provide important information on the spatial impact of each métier.

Given the way it has been computed, the picture given by the partial Fs mainly reflects the relative contribution of each métier x area to the total catch of the stock and includes the information about the trend over the years in F given by the annual stock assessment model.

The full table is available in the EWG ftp, and the results for 2015 and 2019 for the main country-métier and the main species are given for illustration in Annex 1. The following graphs only show the partial Fs. Since the Harvest rates were very similar, the younger ages likely contributed the least to the total biomass.

Results by Métier

Figures 3.5-3.7 provide the partial Fs for cod, haddock and whiting for the first 12 métiers based on the average partial Fs for cod over 2015-2019.

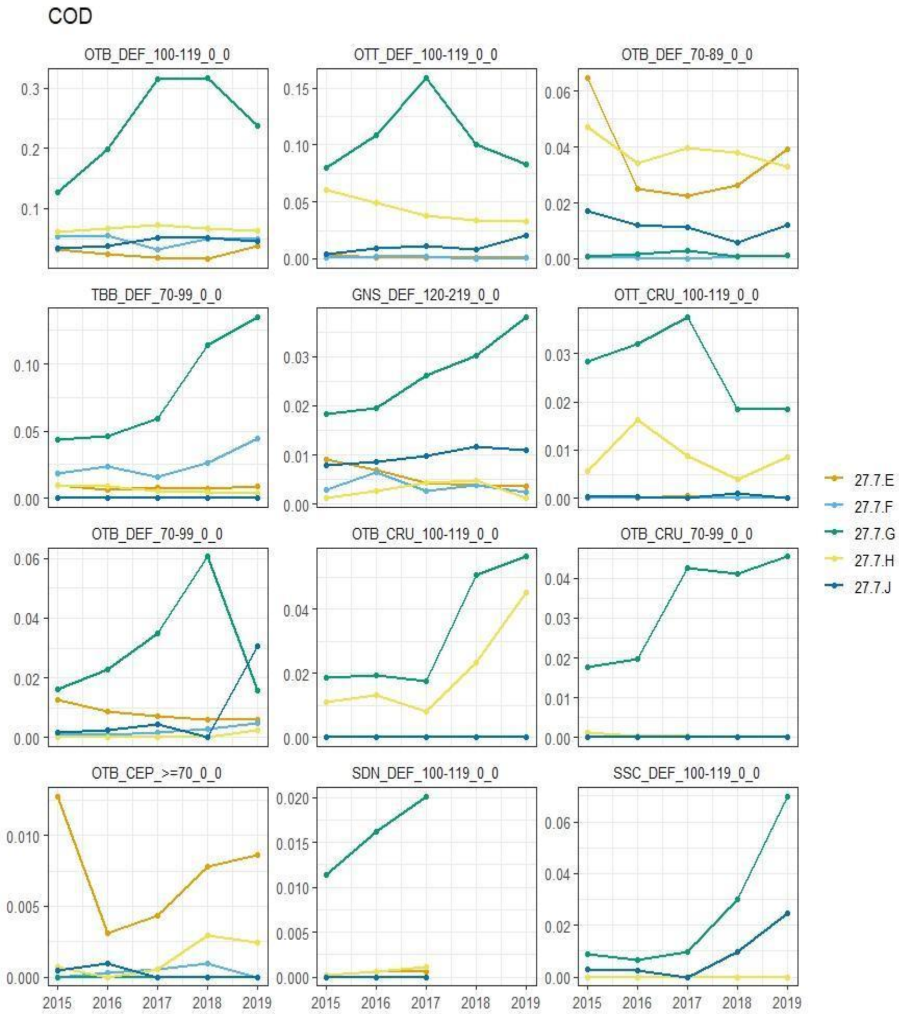

Figure 3.5. Partial Fs for cod (for the top 12 métiers based on average partial F (2015-19)). [Note that the scales are different]

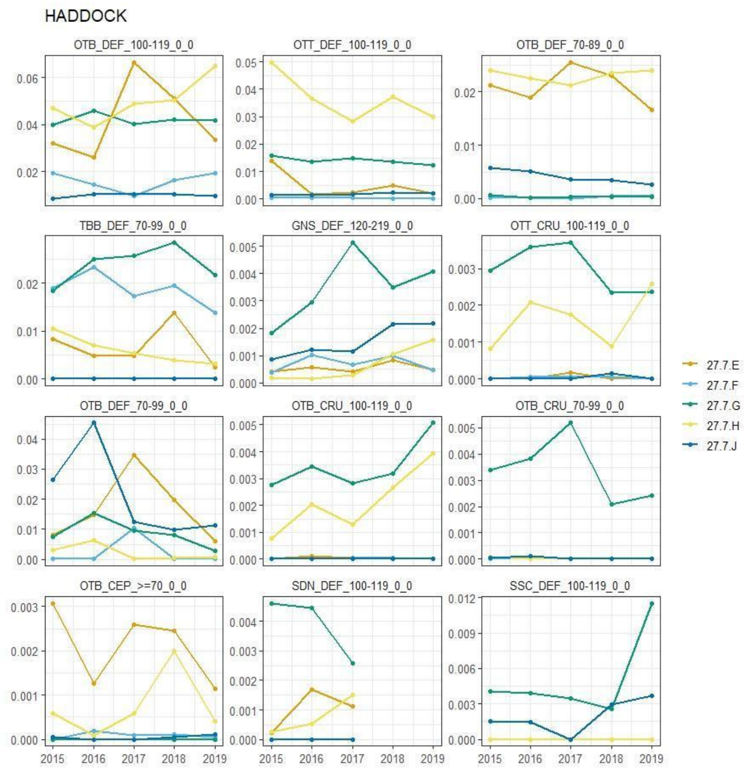

Figure 3.6. Partial Fs for haddock (for the top12 métiers based on based on average partial F (2015-19)). [Note that the scales are different]

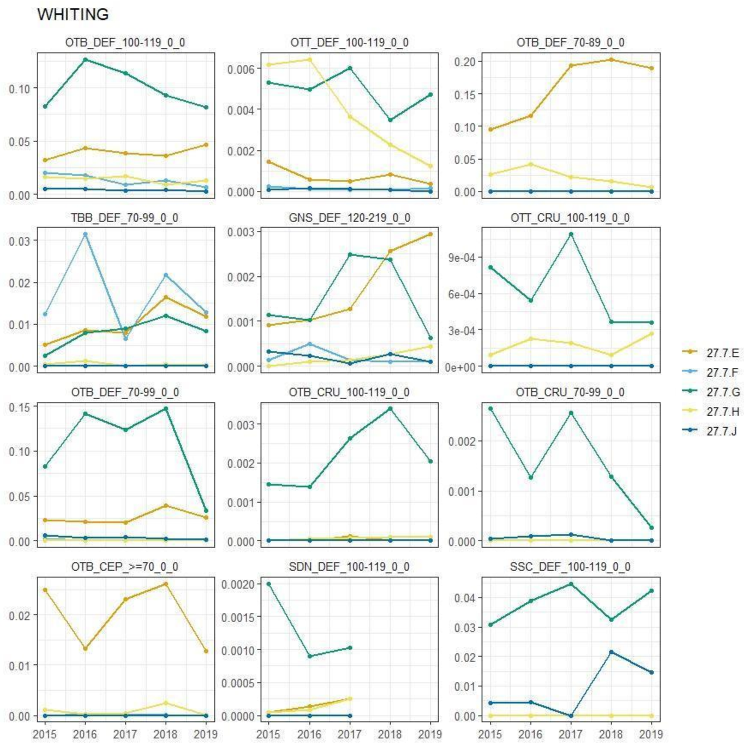

Figure 3.7. Partial Fs for whiting (for the top 12 métiers based on average partial F 2015-2019). [Note that the scales are different]

Not surprisingly, the larger mesh-size (100-119mm) trawlers have the highest partial Fs for cod and haddock, while smaller mesh-size (70-99mm) contributes more to whiting. These Fs over the 2015-2019 period examined peaked in 2017-2018 for cod, 2016 for whiting, and 2017 for haddock.

It is also seen that 27.7.g is by far the area in which the partial F for cod is the highest, while the fishing mortality for whiting is mostly in 27.7.g and 27.7.e (e.g. French and UK coastal areas), and is more spread for haddock (27.7.e,g,h) and very minor in 27.7.j.

Results by Country-Métier

Figure 3.8. Contribution of the main country-métier to the catches of cod, haddock and whiting.

Figure 3.9-3.11 provides the partial Fs for the first 12 country-métiers based on the average partial Fs for cod over 2015-2019.

These figures clearly show the diversity in terms of the main species caught, the main areas fished among countries and métiers. Main contributor métiers show a decrease in the partial F for cod in 2019.

Figure 3.9. Partial Fs for Cod (for the top12 country-métiers). [Note that the scales are different]

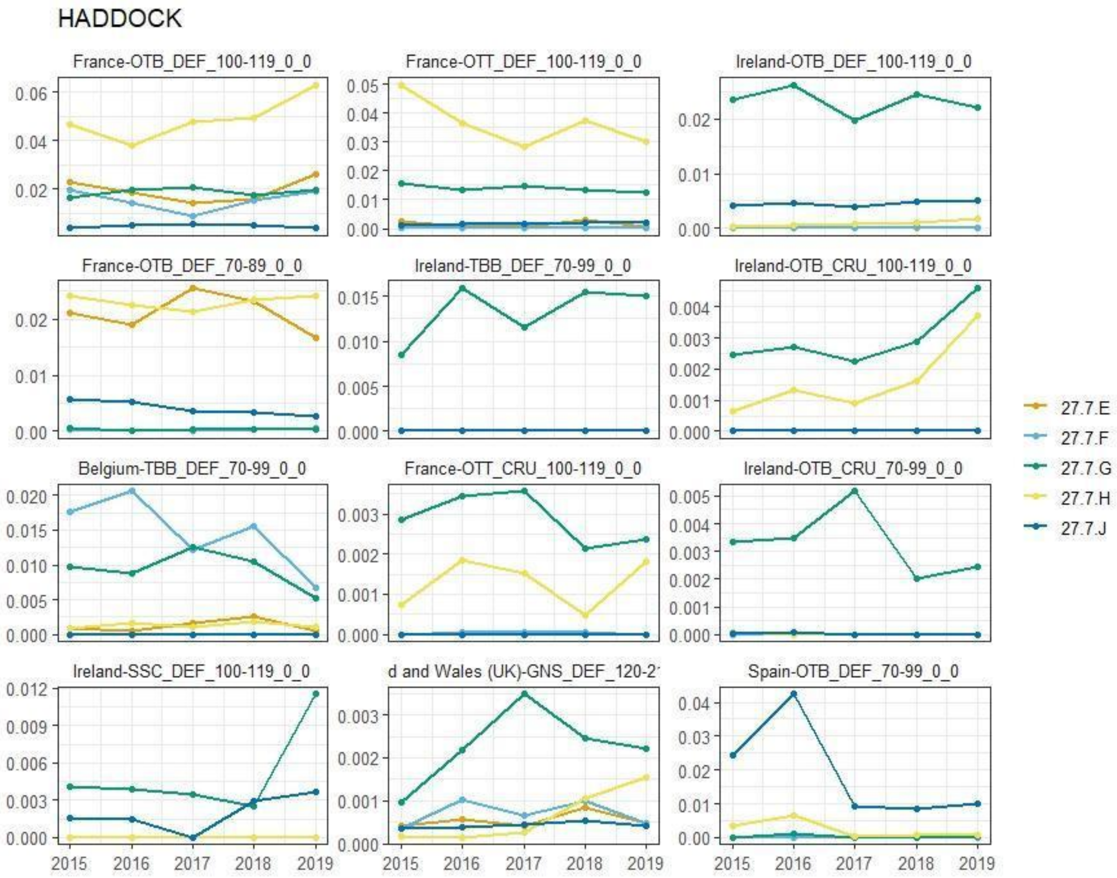

Figure 3.10. Partial Fs for Haddock (for the top12 country-métiers). [Note that the scales are different]

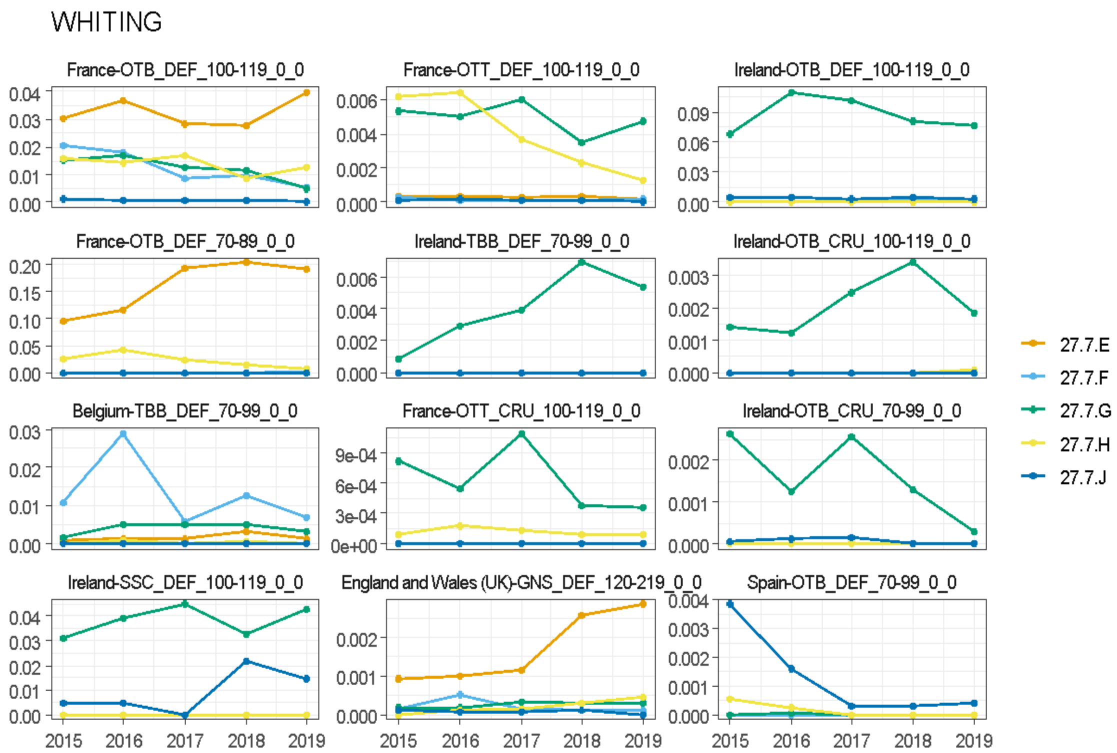

Figure 3.11. Partial Fs for Whiting (for the top12 country-métiers). [Note that the scales are different]

3.2 Catch threshold analysis on the NWW MS group dataset

In the TM Regulation, trip-catch composition thresholds are defined and used to delineate the so-called "directed fisheries". Directed fisheries operating in the Celtic Sea have to use baseline gears specifications listed in the TM Reg Annex VI Part B Table. Besides this, the trip-catch composition is also used to trigger particular specifications that could apply in special areas. Hence, in the remedial measures deployed for cod and whiting, Art. 15b stipulate that "in addition to measures referred to in point (a), Union vessels fishing with bottom trawls whose catches, measured before any discards, consist of at least 20% of haddock shall use: (i) fishing gear that is constructed with a minimum of one metre spacing between the fishing line and ground gear; or (ii) any means proven to be at least equally selective for avoidance of cod, according to the assessment by ICES or the STECF, and approved by the Commission."

Therefore, the use of a "one-meter spaced fishing line" or any alternative gear specifications is currently dependent on a trip-catch composition threshold on haddock. Hereafter we analyse what could have been the potential in protecting tons of cod and the short-term economic implication on the fraction of impacted vessels and trips concerned by that the implementation of this requirement. EWG 21-18 also investigated over a range of catch threshold values, either on haddock or on other species, as long as other species might cover the same amount of tons cod or whiting under the regulation.

Summary of the dataset provided to STECF EWG by the NWW MS group

The dataset collates trip- anonymized vessel-, annual- and month-based data for fishing effort, landed kilos and monetary value for the set of ICES rectangles visited by Belgium, France, Ireland, and Spain fleets over the 2017-2019 period, for all countries, and also 2020 for Spain and Ireland. The DCF métier is also informed at level 6 (i.e. gear types and mesh sizes). UK data are missing even if UK fisheries are a significant part of landings originated from the study area (see the contribution by fleets in ToR 1.1).

The dataset is issued from collating logbooks information collecting living weight landed per species per ICES rectangle as required by logbooks, subsetted for the Celtic Sea area. The logbooks data used in the merging have been assigned to the Art. 15 geographical sectors based on a list of ICEs rectangles impacted by the Regulation defining the CSPZ and for which fishing trips were observed. The logbooks were coupled with vessel-based VMS data to assign for each trip the part of the trips lying within the CSPZ and the one lying outside, and further coupled to sales slips for giving Euros of the catches, assigned back to the ICES rectangles. Hence the dataset comprises possibly several rows on a given trip along with i) several species catch reported for this trip, ii) each time a trip is outside and is inside the regulated CSPZ area. The formatting of the data follows the procedure described by the NWW MS group (link).

Experts comments on the NWW MS group dataset

Experts observed that the dataset is at the right level of resolution in time and space to address the ToRs, including the DCF level 6 information required by Art 15 of the Regulation to identify the relative contribution of trawlers, seiners and other gears to the catches. The experts note that the data provided consists of records of landings and not catches, i.e. discards are not included.

Besides this, because the EWG 21-18 has no access to the raw data, experts had to assume that the spatial allocation in agreement with area specifications defined by Article 15 has been done correctly across all countries and that the assignment of records to ICES rectangle locations has been based on a coupling to VMS data. The VMS data is required to provide the overlap for ICES subdivisions 27.7.j and 27.7.g, with the CSPZ not precisely matching the area zonation. The experts were also notified that the consistency of the effort metrics is not ensured when comparing Irish effort metrics with the other countries data.

Finally, the experts observed that the Technical Measure Regulation of 2019 entered into force after collecting data, limiting its possible effects in explaining the 2017-2019 time development.

The top 15 catch composition within the Celtic Sea Protection Zone (CSPZ) by all gears during 2017-2019 show that hake was predominant both in landed amount and value, followed by whiting herring and megrims (Table 3.1). Nephrops is the second most important in value.

Table 3.1. Top 15 species landed (ALL GEARS) in tonnes originated from the CSPZ in 2017-2019, with corresponding monetary value.

	species	catch_tons	catch_MEURO
63	HKE	27387.7	71.6
170	WHG	12935.0	19.7
62	HER	12733.0	4.0
79	LEZ	10454.4	30.2
96	NEP	10405.7	66.8
150	SPR	9844.7	2.2
60	HAD	8241.1	15.9
5	ANF	8214.0	19.6
89	MNZ	5445.6	24.1
28	COD	3197.5	10.2
135	SCE	3068.1	17.3
31	CRE	3035.6	6.3
171	WIT	2458.6	4.6
84	MAC	2114.8	1.8
110	POL	1641.5	4.3

EWG 21-18 observed that some records in the NWW dataset for Spain are missing the ICES rectangle informed for 1240 cod tons out of 4344.2 tons in total for all countries (Spain, France, Ireland and Belgium) over 2017-2019. These tons are assumed to have been caught outside the CSPZ. Hence, 3318.7 cod tons have been caught by all types of gears within the CSPZ and landed during the period. These cod tonnes were caught during 29323 trips made in the CSPZ, of which 6130 trips crossed the regulated CSPZ area (i.e. trip cover "inside" and "outside" rectangles). The crossing trips represented 1260 tons, while the trips exclusively inside represented 2319.4 tons. The dataset also contains the number of crews per individual vessel informed for 1266 vessels out of 2026.

Among all activities contributing in catching cod the ones using bottom trawls are: OTB_DEF_100_119_0, OTB_DEF_100-119_0_0, OTT_DEF_100_119_0, OTB_DEF_70_99_0, OTB_CRU_70-99_0_0, OTB_DEF_70-99_0_0, OTB_CRU_100-119_0_0, OTT_CRU_100_119_0, OTB_DEF_>=120_0_0, OTB_CEP_70_99_0, OTB_MCD_70-99, for which the Reg Art 15 only applies. (see figure with DCF level 6 activity for bottom trawl -related fleet-segments). (Figure 3.12).

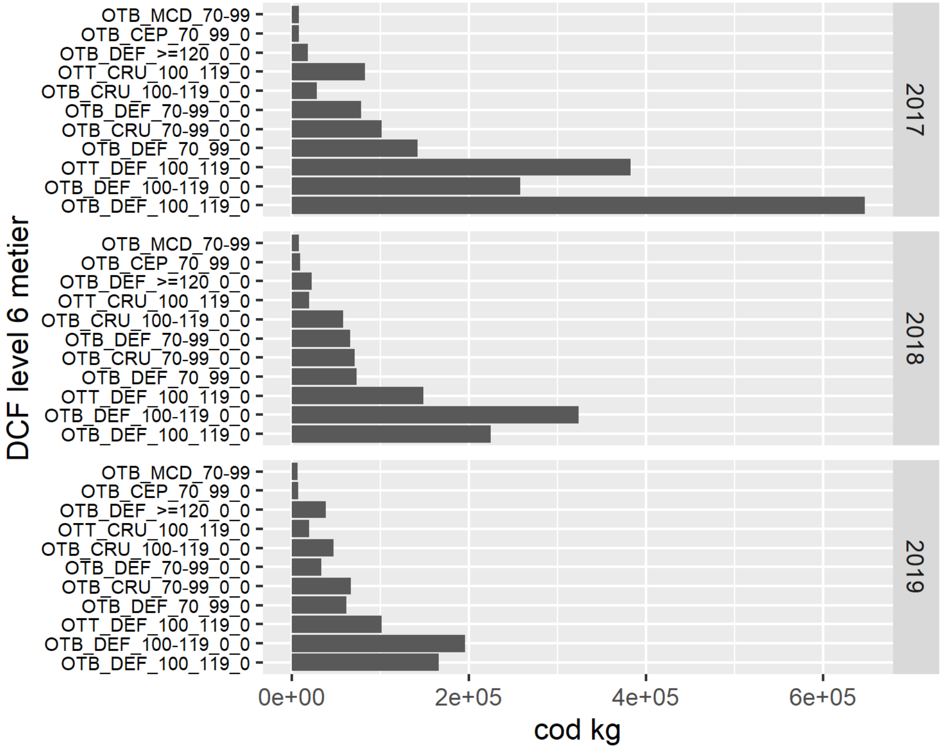

Figure 3.12. Cod landed kg over 2017-2019 declared by demersal trawlers at DCF level 6 segmentation as collated in the NWW MS group dataset.

The group of segments using bottom trawl represent 14533 trips in or crossing the CSPZ, catching 2631 tons of cod during the 2017-2019 period. The top 15 catch composition within the Celtic Sea Protection Zone (CSPZ) shows that catch volume and value are predominant for Nephrops (Table 3.2).

Table 3.2. Top 15 species landed (TRAWLERS) in tonnes originated from the CSPZ in 2017-2019, with corresponding monetary value in millions euros.

	species	catch_tons	catch_MEURO
78	NEP	10326.9	66.3

145	WHG	8731.5	13.4
61	LEZ	7787.0	21.6
44	HAD	6434.3	12.6
47	HKE	5935.5	14.4
3	ANF	5928.4	13.6
71	MNZ	5280.0	23.5
18	COD	2631.2	8.5
146	WIT	1836.9	3.4
67	MEG	1498.9	3.9
57	JOD	1265.7	9.5
60	LEM	1107.7	3.5
94	RAJ	933.3	1.4
104	RJM	932.1	2.0
102	RJH	840.6	1.9

3.2.1 Analysis on trip catch composition

Ahead of STECF PLEN-20-01, France analyzed with its scientific institute IFREMER to evaluate the potential impact of these measures, especially the raised fishing line, on the preservation of cod and its socio-economic impact. This analysis identified the limits of the raised fishing line as it results in a substantial decrease in revenue for the impacted fisheries together with a low gain in terms of cod spared. This was assessed by STECF in March 2020, who concluded that this analysis ideally should be re-run with data from the other Member States to ascertain the broader impacts and benefits of the raised fishing line and the different changes in selectivity implemented.

The impacted vessels depend on a HAD catch % threshold of catch composition as stipulated by Regulation Art. 15. Using a static approach (i.e. looking at realized catches), the below table summarizes the number of impacted vessels and corresponding tons along with these assumptions if the Regulation would have applied during that period. It is shown that if a "perfect knowledge" would be reached (i.e. assuming full knowledge of the theoretical catch composition), then 208 vessels would have been concerned by the Regulation (i.e. the obligation for bottom trawls to carry a "raised fishing line" gear setting when catch composition exceed 20% in Haddock as stipulated in Art 15b). This would end up covering 550 tons of cod exposed to this augmented gear specification.

At the opposite extreme, in the absence of accurate knowledge to identify the fishing events occurring with the CSPZ from the ones outside for the same vessels and trips, therefore accounting for all crossing trips, the Regulation implementing the use of a "raised fishing line" would have resulted in impacting 695 vessels and exposing 3580 tons of cod to the Regulation.

Table 3.3. Static scenarios on impacted vessels by the EU Regulation 2021/92 Art. 15b (2017-2019 data pooled) with different assumptions on concerned vessels.

Scenario	Nb Vessels	Nb Trips	COD tons	HAD tons	WHG tons	Realised Euros (000 Euros)
Perfect knowledge (ie trips inside, >20%HAD)	208	1805	550	2974	752	27099
Concerned vessels only (ie at least 1 trip inside >20%HAD)	208	13794	2524	6452	9054	193535
Concerned vessels only, + all crossing trips	208	13794	2730	10557	9845	246464
Whole fleet, within CSPZ	671	29323	3319	8443	13127	406164
Whole fleet, + all crossing trips	695	29323	3580	13156	14058	543361

The analysis presented further below estimates the amounts of cod that may have been impacted by the regulation Art 15 if it had been applied on Celtic Sea fisheries during 2017-2019, along with varying hypothetical thresholds of catch composition. This cannot be directly interpreted as an actual amount of saved cod that would result from a full implementation of the selective mitigation measures implemented to reduce bycatch of cod in 2020 and 2021. The catch threshold analysis is based on records of catches, and trips catching cod mitigated by the regulation, which would not necessarily mean the cod catch would be 0 for these trips in the studied 2017-2019 period. The catch threshold analysis below characterizes fishing trips, using bottom trawls, with a percentage of the catch composition exceeding a threshold per species within CSPZ. Note that those threshold columns are only valid for the part of the trips within the CSPZ for which Art 15 applies (the "perfect knowledge" scenario in the table above).

Besides the 20% HAD threshold, hereafter, it is explored what would be the corresponding cod tons and value concerned if the threshold on HAD is changed and possible thresholds on other species implemented. Hence, the figure hereafter provides an overview of catch composition patterns concerning a range of thresholds of the proportion of species in landings by trawlers and seiners. The list of species displayed in the analyses is only those appearing in the trips catching more than 20% haddock. Still, the catch threshold analysis is applied to the entire NWW MS group dataset to explore the catch composition of the fisheries in the Celtic Sea. (MNZ = Monkfish, HAD = Haddock, LEZ = Megrims , HKE = Hake, MEG = Megrim, RJM = Spotted ray, RJH = blonde ray, JOD = John Dory, NEP = Nephrops) number of trips crossing the regulated area, number of vessels concerned sum of cod kg in tons, and threshold in a proportion of catches on main species.

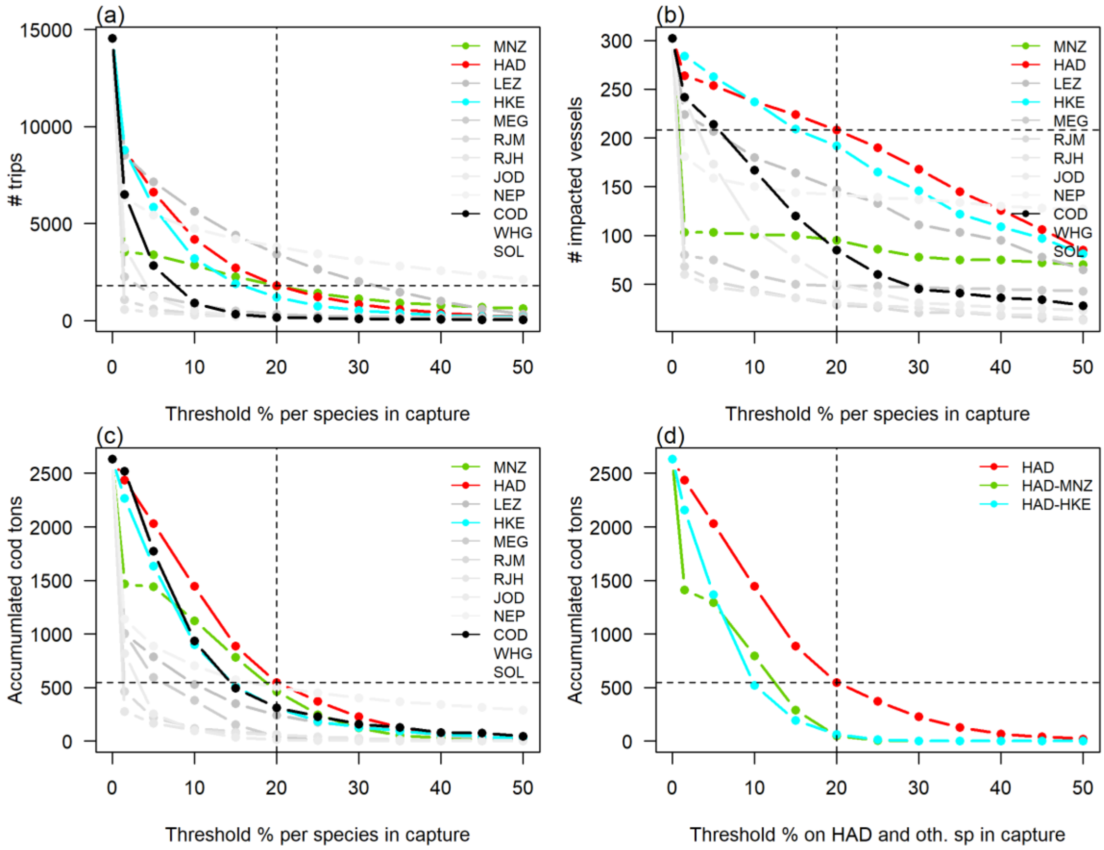

Figure 3.13. Plotting the potential COD saved along with thresholds, and the nb of trips and vessels impacted. Along a threshold in percent of landings per species in international fleet, a) number of impacted trips, b) number of impacted vessels, c) the cumulated landings of cod in tonnes, d) the capture of cod in tonnes along a threshold on the combination of species (e.g., 20% and HAD-MNZ interprets as all the cod tonnes in trips with a threshold of >20% on HAD and a threshold of >20% on MNZ simultaneously). The dashed line gives the 20% threshold on HAD per trip and the corresponding cod landings in tonnes.

From the upper Figure 3.13, it seems that the curves for haddock, monkfish and hake are rather flat or decrease slowly along with higher thresholds. This means that almost all trips and vessels catch these vessels and these species can be considered the primary target species in the Art. 15 regulated areas. Hence, changing to slightly lower threshold values on haddock (or implementing a threshold on monkfish or hake) could save more cod without impacting much more the number of vessels concerned.

Tables 3.4-3.6 below repeat the same information as for Figure 3.13 but in plain numbers. This shows that there could have been 1805 realized trips that could have been potentially impacted by the current regulation requesting a "raised fishing line" for trips exceeding 20% of HAD, which is equivalent or slightly less than the number of trips impacted on other commercially important species such as megrims, hake, whiting and especially Nephrops, as well as less than if this threshold would be set lower, i.e. incorporating other trips not targeting haddock.

Applying the Reg 15(2) would have corresponded to cover 540 tons of cod over the three years pooled under the "raised fishing line specification" with the catch composition threshold of 20% on HAD. The cod tons on other species than the current threshold on >20% HAD are also shown as there might be alternatively equally or more efficient thresholds on other species for covering tons of cod. For example, EWG 21-18 notes that changing the threshold and the species for a threshold on >25% NEP potentially reduces the number of impacted vessels (but also slightly the coverage to 448 tons of cod). However, this would translate into affecting 72 million Euros on NEP instead of 27 million Euros on HAD when considering the revenue corresponding to these thresholds.

EWG 21-18 also notes that a 10% threshold on WHG could have ended to cover 935 tons of cod. Albeit covering more cod tons, this might not be worth it as this would impact more vessels and trips and is still less than the 1444 tons of cod covered by trips with >10% HAD. This could still be of importance when considering the revenue corresponding to these thresholds. Hence, the analysis (see ALL SPECIES table) shows that 27 million euros have been covered by the trips exceeding 20% in HAD. In contrast, 41 million has been covered by the set of trips exceeding 10% in WHG, making it less attractive to impact the whiting-dominant trips (which is true both for a 10% or a 20% threshold).

Hence, the present static analysis may conclude that the most appropriate species for setting a catch threshold is indeed haddock both in terms of cod tons covered and impact on historical revenue minimized. The specific >20% HAD and currently specified in the current Regulation affects fewer trips and vessels while still outperforming the potential thresholds on any other species.

France and Ireland are the two affected countries by the regulation, with 1038 trips of 80 vessels for France and 767 trips of 128 concerned vessels for Ireland. The following tables split the potential of trips impacted by country (Table 3.5).

Table 3.4. Overall Impact

Nb trips impacted *(2017-2019), in bottom trawls trips within the CSPZ, along with thresholds in catch composition for different species:*

	>0%	>1.5%	>5%	>10%	>15%	>20%	>25%	>30%	>35%	>40%	>45%	>50%
MNZ	14533	3537	3399	2866	2270	1788	1410	1132	925	799	695	617
HAD	14533	8768	6629	4189	2722	**1805**	1238	845	576	394	268	189
LEZ	14533	8517	7152	5634	4399	3429	2637	2030	1468	1007	611	329
HKE	14533	8779	5840	3196	1912	1205	755	527	383	291	226	178
MEG	14533	2259	1280	840	512	325	244	204	182	171	160	147
RJM	14533	1073	609	363	251	172	131	86	64	49	34	27
RJH	14533	587	417	292	219	167	125	89	62	45	34	20
JOD	14533	3744	1227	516	225	119	77	60	54	48	47	45
NEP	14533	6329	5436	4731	4211	3804	3449	3115	2823	2587	2348	2121
COD	14533	6500	2842	910	340	180	120	87	77	61	57	49
WHG	14533	6035	4062	2851	2220	1794	1565	1368	1196	1071	965	872
SOL	14533	2516	1145	526	260	136	74	50	35	25	20	19

Nb vessels impacted *(2017-2019), in bottom trawls trips within the CSPZ, along with thresholds in catch composition for different species:*

	>0%	>1.5%	>5%	>10%	>15%	>20%	>25%	>30%	>35%	>40%	>45%	>50%

MNZ	302	103	103	101	100	95	86	78	75	75	72	70
HAD	302	264	254	237	224	**208**	190	168	145	126	106	85
LEZ	302	224	207	180	164	147	133	111	103	95	78	65
HKE	302	284	263	237	209	192	165	146	122	109	97	81
MEG	302	80	75	60	50	48	48	47	45	45	44	43
RJM	302	68	53	44	36	29	26	21	21	18	15	14
RJH	302	60	47	42	36	31	28	26	22	19	18	13
JOD	302	240	173	106	76	51	41	31	29	26	25	23
NEP	302	181	159	150	144	142	139	137	134	130	128	127
COD	302	242	214	167	120	85	60	45	41	36	34	28
WHG	302	221	202	171	155	133	113	103	95	81	69	62
SOL	302	183	91	61	44	38	26	21	18	15	14	14

Millions euros of ALL SPECIES *(2017-2019), in bottom trawls trips within the CSPZ, along with thresholds in catch composition for different species:*

	>0%	>1.5%	>5%	>10%	>15%	>20%	>25%	>30%	>35%	>40%	>45%	>50%
MNZ	222	84	81	69	53	39	27	18	12	9	6	4
HAD	222	169	116	69	43	27	18	12	8	5	3	2
LEZ	222	112	87	67	53	43	35	29	21	13	7	3
HKE	222	163	103	55	32	20	12	8	6	4	3	2
MEG	222	54	32	20	9	3	1	0	0	0	0	0
RJM	222	27	15	9	6	4	3	2	1	1	0	0
RJH	222	17	12	8	6	5	4	2	2	1	1	0
JOD	222	67	21	9	4	1	1	0	0	0	0	0
NEP	222	110	97	87	80	76	72	68	64	62	59	55
COD	222	145	57	17	6	3	2	1	1	0	0	0
WHG	222	99	60	41	31	25	21	18	16	15	13	12
SOL	222	27	8	4	2	1	1	0	0	0	0	0

***Catch tons of cod** (2017-2019), in bottom trawls trips within the CSPZ, along with thresholds in catch composition for different species:*

	>0%	>1.5%	>5%	>10%	>15%	>20%	>25%	>30%	>35%	>40%	>45%	>50%
MNZ	2631	1466	1442	1124	783	463	247	122	53	30	15	8
HAD	2631	2437	2029	1444	885	**547**	372	226	128	66	39	20
LEZ	2631	1005	786	531	349	240	175	137	98	53	27	7
HKE	2631	2264	1635	899	512	310	184	128	94	61	42	25
MEG	2631	1002	596	380	154	40	11	5	4	1	1	0
RJM	2631	463	221	120	85	61	39	18	11	4	2	1
RJH	2631	275	168	99	74	56	39	27	13	8	4	3
JOD	2631	817	254	103	35	12	5	3	2	1	1	1
NEP	2631	1142	886	702	573	502	448	404	368	341	315	289
COD	2631	2521	1771	935	493	312	229	158	126	79	76	45
WHG	2631	1623	1027	651	446	320	247	201	167	144	127	111
SOL	2631	177	30	13	7	4	1	1	0	0	0	0

***Millions euros of cod** (2017-2019), in bottom trawls trips within the CSPZ, along with thresholds in catch composition for different species:*

	>0%	>1.5%	>5%	>10%	>15%	>20%	>25%	>30%	>35%	>40%	>45%	>50%
MNZ	9	5	5	4	3	2	1	0	0	0	0	0
HAD	9	8	7	5	3	**2**	1	1	0	0	0	0
LEZ	9	3	2	2	1	1	1	0	0	0	0	0
HKE	9	7	5	3	2	1	1	0	0	0	0	0
MEG	9	4	2	1	1	0	0	0	0	0	0	0
RJM	9	2	1	0	0	0	0	0	0	0	0	0
RJH	9	1	1	0	0	0	0	0	0	0	0	0
JOD	9	3	1	0	0	0	0	0	0	0	0	0
NEP	9	4	3	2	2	1	1	1	1	1	1	1
COD	9	8	6	3	1	1	1	0	0	0	0	0
WHG	9	5	3	2	1	1	1	1	0	0	0	0

SOL	9	1	0	0	0	0	0	0	0	0	0	0

Table 3.5. Impact by country.

Nb trips impacted per country *(2017-2019), in bottom trawls trips within the CSPZ, along with thresholds in catch composition for different species:*

	>0%	>1.5%	>5%	>10%	>15%	>20%	>25%	>30%	>35%	>40%	>45%	>50%
FR HAD	4152	2732	2379	1917	1424	1038	745	508	340	231	152	102
ESP HAD	578	59	13	1	0	0	0	0	0	0	0	0
IRL HAD	9714	5920	4200	2265	1298	767	493	337	236	163	116	87
BEL HAD	89	57	37	6	0	0	0	0	0	0	0	0

Nb vessels impacted per country *(2017-2019), in bottom trawls trips within the CSPZ, along with thresholds in catch composition for different species:*

	>0%	>1.5%	>5%	>10%	>15%	>20%	>25%	>30%	>35%	>40%	>45%	>50%
FR HAD	106	96	94	90	86	80	76	72	68	60	53	43
ESP HAD	27	9	6	1	0	0	0	0	0	0	0	0
IRL HAD	162	153	148	142	138	128	114	96	77	66	53	42
BEL HAD	7	6	6	4	0	0	0	0	0	0	0	0

Catch tons of cod *per country (2017-2019), in bottom trawls trips within the CSPZ, along with thresholds in catch composition for different species:*

	>0%	>1.5%	>5%	>10%	>15%	>20%	>25%	>30%	>35%	>40%	>45%	>50%
FRA HAD	1473	1412	1313	1087	703	458	320	195	108	54	31	14
ESP HAD	12	7	3	0	0	0	0	0	0	0	0	0
IRL HAD	1123	999	699	356	182	89	51	30	20	12	8	6
BEL HAD	22	19	14	1	0	0	0	0	0	0	0	0

Table 3.6. Impact by species in catch and revenue.

Catch tons of whiting *(2017-2019), in bottom trawls trips within the CSPZ, along with thresholds in catch composition for different species:*

	>0%	>1.5%	>5%	>10%	>15%	>20%	>25%	>30%	>35%	>40%	>45%	>50%
MNZ	8731	982	841	504	279	161	90	39	15	8	5	2
HAD	8731	6187	3875	2017	1162	750	539	362	221	144	85	47
LEZ	8731	3084	1355	586	276	157	100	67	42	24	15	5
HKE	8731	5755	3070	1483	741	381	192	106	64	42	26	16
MEG	8731	495	206	98	32	9	3	1	0	0	0	0
RJM	8731	423	213	104	71	47	30	11	7	3	1	0
RJH	8731	418	269	139	88	65	46	34	21	12	7	3
JOD	8731	1694	273	73	29	8	2	1	1	0	0	0
NEP	8731	2304	1279	898	739	628	526	431	355	322	271	223
COD	8731	4279	1289	382	161	92	57	35	21	11	11	5
WHG	8731	8640	8306	7880	7494	7136	6872	6593	6301	6082	5842	5630
SOL	8731	379	131	52	23	7	2	1	0	0	0	0

Millions euros of whiting *(2017-2019), in bottom trawls trips within the CSPZ, along with thresholds in catch composition for different species:*

	>0%	>1.5%	>5%	>10%	>15%	>20%	>25%	>30%	>35%	>40%	>45%	>50%
MNZ	13	2	2	1	1	0	0	0	0	0	0	0
HAD	13	10	6	4	2	1	1	1	0	0	0	0
LEZ	13	5	2	1	0	0	0	0	0	0	0	0
HKE	13	9	5	2	1	1	0	0	0	0	0	0
MEG	13	1	0	0	0	0	0	0	0	0	0	0
RJM	13	1	0	0	0	0	0	0	0	0	0	0
RJH	13	1	1	0	0	0	0	0	0	0	0	0
JOD	13	3	1	0	0	0	0	0	0	0	0	0
NEP	13	3	2	1	1	1	1	1	1	0	0	0
COD	13	7	2	1	0	0	0	0	0	0	0	0
WHG	13	13	13	12	11	11	10	10	9	9	8	8
SOL	13	1	0	0	0	0	0	0	0	0	0	0

***Catch tons of haddock** (2017-2019), in bottom trawls trips within the CSPZ, along with thresholds in catch composition for different species:*

	>0%	>1.5%	>5%	>10%	>15%	>20%	>25%	>30%	>35%	>40%	>45%	>50%
MNZ	6434	3933	3692	2718	1614	900	445	220	96	49	28	17
HAD	6434	6384	5906	4897	3857	2966	2322	1739	1261	892	615	413
LEZ	6434	2105	1597	1107	768	554	412	312	211	120	66	19
HKE	6434	5676	3933	2075	1223	744	439	297	211	140	99	62
MEG	6434	2835	1420	900	433	142	44	11	4	1	1	0
RJM	6434	1493	774	416	247	148	97	50	28	13	5	2
RJH	6434	699	404	223	145	102	72	38	17	12	8	5
JOD	6434	2513	1096	466	142	41	17	8	5	3	3	2
NEP	6434	2012	1501	1159	913	757	657	570	504	461	414	373
COD	6434	5323	2516	851	328	167	116	60	37	17	16	9
WHG	6434	4072	2387	1634	1171	870	696	571	486	436	368	321
SOL	6434	602	117	49	24	9	2	1	1	0	0	0

***Millions euros of haddock** (2017-2019), in in bottom trawls trips within the CSPZ, along with thresholds in catch composition for different species:*

	>0%	>1.5%	>5%	>10%	>15%	>20%	>25%	>30%	>35%	>40%	>45%	>50%
MNZ	13	8	8	6	3	2	1	0	0	0	0	0
HAD	13	13	12	10	8	6	5	4	3	2	1	1
LEZ	13	4	3	2	1	1	1	1	0	0	0	0
HKE	13	11	8	4	2	2	1	1	0	0	0	0
MEG	13	6	3	2	1	0	0	0	0	0	0	0
RJM	13	3	2	1	1	0	0	0	0	0	0	0
RJH	13	2	1	1	0	0	0	0	0	0	0	0
JOD	13	5	2	1	0	0	0	0	0	0	0	0
NEP	13	4	3	2	2	1	1	1	1	1	1	1
COD	13	11	5	2	1	0	0	0	0	0	0	0

WHG	13	8	5	3	2	2	1	1	1	1	1	1
SOL	13	1	0	0	0	0	0	0	0	0	0	0

Catch tons of Nephrops *(2017-2019), in trawls and seines trips within the CSPZ, along with thresholds in catch composition for different species:*

	>0%	>1.5%	>5%	>10%	>15%	>20%	>25%	>30%	>35%	>40%	>45%	>50%
MNZ	6434	3933	3692	2718	1614	900	445	220	96	49	28	17
HAD	6434	6384	5906	4897	3857	2966	2322	1739	1261	892	615	413
LEZ	6434	2105	1597	1107	768	554	412	312	211	120	66	19
HKE	6434	5676	3933	2075	1223	744	439	297	211	140	99	62
MEG	6434	2835	1420	900	433	142	44	11	4	1	1	0
RJM	6434	1493	774	416	247	148	97	50	28	13	5	2
RJH	6434	699	404	223	145	102	72	38	17	12	8	5
JOD	6434	2513	1096	466	142	41	17	8	5	3	3	2
NEP	6434	2012	1501	1159	913	757	657	570	504	461	414	373
COD	6434	5323	2516	851	328	167	116	60	37	17	16	9
WHG	6434	4072	2387	1634	1171	870	696	571	486	436	368	321
SOL	6434	602	117	49	24	9	2	1	1	0	0	0

Millions euros of Nephrops *(2017-2019), in trawls and seines trips within the CSPZ, along with thresholds in catch composition for different species*

	>0%	>1.5%	>5%	>10%	>15%	>20%	>25%	>30%	>35%	>40%	>45%	>50%
MNZ	66	4	4	4	4	2	1	0	0	0	0	0
HAD	66	45	22	8	3	1	1	0	0	0	0	0
LEZ	66	32	18	10	5	2	1	1	0	0	0	0
HKE	66	34	15	6	3	1	1	0	0	0	0	0
MEG	66	4	4	3	1	0	0	0	0	0	0	0
RJM	66	0	0	0	0	0	0	0	0	0	0	0
RJH	66	0	0	0	0	0	0	0	0	0	0	0
JOD	66	10	2	0	0	0	0	0	0	0	0	0

NEP	66	66	65	63	62	60	58	57	55	53	51	49
COD	66	46	13	2	0	0	0	0	0	0	0	0
WHG	66	19	12	7	4	3	2	2	1	1	1	1
SOL	66	3	0	0	0	0	0	0	0	0	0	0

***Catch tons of hake** (2017-2019), in trawls and seines trips within the CSPZ, along with thresholds in catch composition for different species:*

	>0%	>1.5%	>5%	>10%	>15%	>20%	>25%	>30%	>35%	>40%	>45%	>50%
MNZ	5936	2730	2675	2281	1544	995	622	365	191	124	76	47
HAD	5936	4645	3659	2388	1457	886	574	359	229	149	82	51
LEZ	5936	3320	2886	2279	1861	1569	1301	1090	804	496	278	114
HKE	5936	5867	5282	4097	3108	2358	1712	1340	1043	812	656	500
MEG	5936	2034	1130	692	294	102	30	12	9	5	5	0
RJM	5936	504	254	123	73	43	27	13	8	4	2	1
RJH	5936	237	128	75	47	32	19	8	5	2	1	0
JOD	5936	1964	461	161	53	16	6	3	2	1	1	1
NEP	5936	1875	1357	948	718	601	503	421	341	290	244	209
COD	5936	4008	2016	593	156	66	35	22	16	9	9	4
WHG	5936	3105	1757	1182	871	683	565	465	373	324	277	246
SOL	5936	413	63	15	5	1	0	0	0	0	0	0

***Millions euros of hake** (2017-2019), in trawls and seines trips within the CSPZ, along with thresholds in catch composition for different species:*

	>0%	>1.5%	>5%	>10%	>15%	>20%	>25%	>30%	>35%	>40%	>45%	>50%
MNZ	14	7	6	5	4	2	2	1	1	0	0	0
HAD	14	12	9	6	4	2	1	1	1	0	0	0
LEZ	14	8	7	6	5	4	3	2	2	1	1	0
HKE	14	14	13	10	8	6	4	3	3	2	2	1
MEG	14	5	3	2	1	0	0	0	0	0	0	0
RJM	14	1	1	0	0	0	0	0	0	0	0	0

RJH	14	1	0	0	0	0	0	0	0	0	0	0
JOD	14	5	1	0	0	0	0	0	0	0	0	0
NEP	14	4	3	2	2	1	1	1	1	1	1	0
COD	14	10	5	1	0	0	0	0	0	0	0	0
WHG	14	8	4	3	2	2	1	1	1	1	1	1
SOL	14	1	0	0	0	0	0	0	0	0	0	0

Catch tons of Monkfish *(2017-2019), in trawls and seines trips within the CSPZ, along with thresholds in catch composition for different species:*

	>0%	>1.5%	>5%	>10%	>15%	>20%	>25%	>30%	>35%	>40%	>45%	>50%
MNZ	5280	5280	5243	4899	4259	3506	2667	1994	1436	1146	871	649
HAD	5280	4237	3257	2329	1480	920	608	380	229	135	76	40
LEZ	5280	1581	1533	1477	1430	1351	1208	939	612	279	116	32
HKE	5280	4742	3231	1773	1011	667	379	273	186	129	91	57
MEG	5280	3201	2226	1416	652	215	85	34	23	14	13	1
RJM	5280	1056	548	293	196	132	94	52	31	18	8	4
RJH	5280	667	448	285	195	151	110	78	49	32	17	9
JOD	5280	1804	594	258	90	31	13	6	3	2	2	2
NEP	5280	1380	851	521	293	162	84	36	11	8	3	3
COD	5280	3581	1783	690	248	114	60	33	25	12	10	4
WHG	5280	1868	674	277	141	70	36	21	16	9	5	2
SOL	5280	693	8	1	0	0	0	0	0	0	0	0

Millions euros of Monkfish *(2017-2019), in trawls and seines trips within the CSPZ, along with thresholds in catch composition for different species:*

	>0%	>1.5%	>5%	>10%	>15%	>20%	>25%	>30%	>35%	>40%	>45%	>50%
MNZ	23	23	23	22	19	16	13	10	7	6	4	3
HAD	23	19	14	9	6	4	3	2	1	1	0	0
LEZ	23	8	8	8	7	7	6	5	3	1	1	0
HKE	23	21	14	8	4	3	2	1	1	1	0	0

MEG	23	13	9	6	3	1	0	0	0	0	0	0
RJM	23	5	2	1	1	1	0	0	0	0	0	0
RJH	23	3	2	1	1	1	0	0	0	0	0	0
JOD	23	8	2	1	0	0	0	0	0	0	0	0
NEP	23	6	3	2	1	1	0	0	0	0	0	0
COD	23	15	7	3	1	0	0	0	0	0	0	0
WHG	23	8	3	1	1	0	0	0	0	0	0	0
SOL	23	3	0	0	0	0	0	0	0	0	0	0

Catch tons of Megrim *(2017-2019), in trawls and seines trips within the CSPZ, along with thresholds in catch composition for different species:*

	>0%	>1.5%	>5%	>10%	>15%	>20%	>25%	>30%	>35%	>40%	>45%	>50%
MNZ	1499	1480	1471	1386	1142	777	416	212	89	36	22	15
HAD	1499	1420	1265	948	608	359	237	139	90	55	35	19
LEZ	1499	3	1	1	1	0	0	0	0	0	0	0
HKE	1499	1394	1075	645	344	218	118	75	56	38	27	12
MEG	1499	1460	1268	1000	582	259	124	66	51	38	37	20
RJM	1499	273	127	59	34	21	16	7	4	3	1	1
RJH	1499	183	114	66	47	35	25	17	10	6	3	2
JOD	1499	461	144	56	21	7	3	2	1	1	1	0
NEP	1499	808	550	343	198	110	56	25	8	6	1	1
COD	1499	1260	675	248	69	28	12	6	5	2	1	1
WHG	1499	604	162	48	21	10	4	2	2	1	0	0
SOL	1499	247	2	0	0	0	0	0	0	0	0	0

Millions euros of Megrim *(2017-2019), in trawls and seines trips within the CSPZ, along with thresholds in catch composition for different species:*

	>0%	>1.5%	>5%	>10%	>15%	>20%	>25%	>30%	>35%	>40%	>45%	>50%
MNZ	4	4	4	4	3	2	1	1	0	0	0	0
HAD	4	4	3	2	1	1	1	0	0	0	0	0

LEZ	4	0	0	0	0	0	0	0	0	0	0
HKE	4	4	3	2	1	1	0	0	0	0	0
MEG	4	4	3	2	1	1	0	0	0	0	0
RJM	4	1	0	0	0	0	0	0	0	0	0
RJH	4	1	0	0	0	0	0	0	0	0	0
JOD	4	1	0	0	0	0	0	0	0	0	0
NEP	4	2	1	1	0	0	0	0	0	0	0
COD	4	3	2	1	0	0	0	0	0	0	0
WHG	4	2	1	0	0	0	0	0	0	0	0
SOL	4	1	0	0	0	0	0	0	0	0	0

3.2.2 Exploring the impact of the addition of a maximum % of COD per fishing trip

Art 15(2) also stipulates a trip bycatch limit on cod of 1.5%: "Member States may exempt from the application of point (b) of paragraph 1 vessels fishing with bottom trawls whose catches, measured before any discards, consist of less than 1.5% of cod, provided that those vessels are subject to a progressive increase of observer coverage at sea up to at least 20% of all their fishing trips as of 1 July 2021".

Analysing the NWW MS group dataset for each trip falling under Art 15, and where the observed ratio of the catch composition is below the limit for cod and above limit for haddock, possible new COD catch (Table below) is simulated to respect the limit (here 1.5% as in the Regulation, or with an alternative at 5%). Formula to calculate simulated COD takes into account the TOTAL reduction due to COD catches reduction. All assumptions put apart (see discussion in STECF-PLEN-20-01), this static analysis shows that the potential of cod that could have been saved by implementing the 1.5% threshold on cod all years pooled is 2740 tons. This would have amounted to 5457 tons if the threshold had been raised to 5%.

2017-2019 potentials for the amount of saved COD tons if 1.5 or 5% threshold on cod for all trips with HAD > 20% in the entire Celtic Sea area:

Threshold %	Saved COD tons
1.5	-2740
5.0	-5457

3.3 References

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4 ToR 2. As regarding seasonal closures of relevant parts of the Celtic Sea Protection Zone

This term of reference has two objectives: (i) to evaluate the existing closed area for the conservation of cod in ICES divisions 27.7.f and 27.7.g (Regulation (EU) 2019/1241) and (ii) to explore alternative closures in duration, season and geography in the Celtic Sea.

EWG 21-18 first mapped persistent hotspot areas for the species of interest using fisheries-independent scientific survey data, further complementing the available NWW MS group commercial dataset. However, as the scientific survey only occurs during Autumn (ICES, 2021), the time coverage for other seasons is only reachable by integrating commercial data with data of broader time coverage. Commercial data, however, could come with a bias toward preferential sampling (i.e. fishers are not used for fishing randomly but focusing on their fishing grounds).

Using this new information, the EWG 21-18 discussed evaluating the efficiency of the historical "Trevose closure" in protecting cod. The Trevose closure is implemented, from 2006 onwards, the closure of ICES rectangles 30E4 (removing that part of 30E4 extending into the 6-mile UK limit), 31E4 and 32E3 in February and March only. The EWG 21-18 concluded that the evaluation would remain inconclusive since the lack of accurate data to run the assessment. It was not possible to evaluate the economic impact of such closed areas as no catch and value data informing the situation before 2017 was available to the group.

Using the outcome of the hotspot persistence analysis, the EWG 21-18 investigated alternative locations and timing for closed areas to reduce the fishing mortality that applies on cod and whiting in the Celtic Sea. By also considering the possible relative economic return of the concerned ICES rectangles, The optimisation analysis the EWG 21-18 deployed to answer the ToR showed that a combination of ICES statistical rectangles and months during which the fishery is closed could maximizes the protection of cod and whiting while minimizing the economic impact.

4.1 Data

For this analysis, three different datasets were used:

1. A dataset was compiled that includes the monthly landings and discards of cod, whiting and haddock, revenue and fishing effort by métier (DCF level 6) and member state in the Celtic Sea. This dataset combines information from the FDI (Fisheries Dependent Information) and the NWW MS dataset. The NWW data comprises landings (for all commercial species), revenue, and effort statistics at the trip level for the EU Member States operating in the Celtic Sea for 2017-2020, although 2020 is incomplete. Each trip is linked to a specific month, and landings per trip are distributed over ICES statistical rectangles based on the VMS (Vessel Monitoring System) data.

The NWW dataset was compiled at the Member State level and provided to this EWG. The FDI data (FDI_2020. https://stecf.jrc.ec.europa.eu/dd/fdi) contains quarterly landing and discard statistics by ICES division, member state and métier level for the period 2017-2019. Both data sets were merged in order to disaggregate the FDI discard data by month and ICES statistical rectangle. Hereto, FDI discard estimates were distributed over months and ICES statistical rectangles proportionally to the spatiotemporal distribution of landings by métier as registered in the NWW dataset. There was not a perfect match between both data sets, causing that 5% of cod discards recorded in the FDI could not be allocated. An overview of the data used is provided in Tables 4.1-4.3. Several inconsistencies in the fishery-dependent information were detected between various databases regarding the absolute value of landings and discards estimates. This mismatch occurs between the NWW MS dataset, the FDI database, and another official dataset (Eurostat) and scientific databases (ICES advice sheets). The fishery-dependent information used in the persistency analysis and in the economic impact of this ToR should only be considered for this purpose, as the discrepancies found have not been fully explained. EWG 21-18 noted an underestimation of landings and an underestimation and incomplete records of discards. The effort estimates also present some extreme and inconsistent figures related to the method of calculation used to assign fishing effort to the ICES statistical rectangles.2. A fisheries-independent dataset was retrieved from the online database of trawl surveys DATRAS (ICES, 2021, ttps://datras.ices.dk/Data_products/Download/Download_Data_public.aspx.).The dataset includes the catch in numbers per length and haul (CPUE.n) for cod, whiting and haddock in the CSP derived from scientific surveys conducted over 12 years (2009-2020, only in Q4). The French survey EVHOE and the Irish survey IE-IGFS were selected as they have longer time series of data and cover an important area of the Celtic Sea.

3. A dataset consisted of relative "habitat capacity distribution" layers, averaged over the period 2010–2016 for the functional groups cod juveniles, cod adult, whiting and haddock. Geographical raster layers contain the maximum probability of occurrence as it was predicted by Hernvann et al. (2020) using a novel ecological-niche approach and following the methodology described in Gruss et al. (2020), applying a statistical model that inferred the spatial distribution of cod based on underlying environmental variables, and 1987-2017 International Bottom Trawl Surveys (IBTS) abundance fields.

Table 4.1. Cod, whiting and haddock landings (in tonnes) by métier and country for years 2017-19, selected métiers and selected ICES divisions. Data were derived from the NWW MS dataset.

	COD			WHITING			HADDOCK		
	2017	2018	2019	2017	2018	2019	2017	2018	2019
OTB_DEF_100-119_0_0_FRA	493	216	161	1044	630	704	2041	1857	2311
OTT_DEF_100-119_0_0_FRA	324	147	101	157	69	71	1022	1071	874
OTB_DEF_100-119_0_0_IRL	220	251	165	987	756	850	483	463	519
OTB_DEF_70-99_0_0_FRA	133	72	61	3357	2193	2022	1132	961	851
OTT_CRU_100-119_0_0_FRA	82	19	19	19	5	4	111	50	81
OTB_CRU_70-99_0_0_IRL	80	44	38	54	32	12	107	37	48
OTB_DEF_70-99_0_0_IRL	75	65	19	623	596	221	254	160	85
SSC_DEF_100-119_0_0_IRL	67	91	71	1024	1029	766	228	197	343
TBB_DEF_70-99_0_0_BEL	53	28	24	77	65	43	80	53	58
TBB_DEF_70-99_0_0_IRL	45	71	71	52	68	49	175	186	180
GNS_DEF_120-219_0_0_IRL	35	25	28	132	50	23	110	82	90
OTB_CRU_100-119_0_0_IRL	28	58	47	53	55	26	46	58	90
OTM_DEF_100-119_0_0_FRA	14	8	0	13	28	1	49	50	0
SDN_DEF_100-119_0_0_FRA	10	0	0	24	0	0	60	0	0
GTR_DEF_>=220_0_FRA	10	8	4	7	4	6	1	1	1
OTB_CRU_100-119_0_0_FRA	10	0	0	2	0	0	13	0	0
OTB_DEF_>=120_0_0_IRL	10	16	14	20	7	23	37	31	48
OTB_CEP_70_99_0_FRA	8	10	7	319	259	131	65	67	20
OTB_MCD_70-99_BEL	8	8	6	8	14	17	10	13	10
OTB_DEF_70-99_0_0_ESP	0	0	14	0	0	0	0	0	66

Table 4.2. Cod, whiting and haddock discards (tonnes) by métier and country for years 2017-19, selected métiers and selected ICES divisions. Data after merging the FDI discard data to the NWW dataset.

	COD			WHITING			HADDOCK		
	2017	2018	2019	2017	2018	2019	2017	2018	2019
OTB_DEF_100-119_0_0_IRL	7.6	11.8	7.4	63.1	91.8	34.4	88.7	308.4	56.4
TBB_DEF_70-99_0_0_IRL	6.3	26.1	4.7	16.7	37.2	14.8	99.2	229.8	119.7
TBB_DEF_70-99_0_0_BEL	6.1	12.8	14.3	88.0	245.8	67.7	485.2	927.9	174.5
OTB_DEF_70-99_0_0_IRL	3.2	6.4	1.3	42.9	102.7	6.5	55.2	97.0	16.7
OTB_CRU_70-99_0_0_IRL	1.3	2.2	1.0	0.0	0.4	0.0	18.6	7.3	4.1
OTT_DEF_100-119_0_0_FRA	1.1	0.0	12.1	0.0	0.0	0.0	0.0	0.0	0.0
OTB_CRU_100-119_0_0_IRL	0.6	1.6	0.8	0.0	1.3	2.6	9.0	7.7	6.4
OTB_DEF_100-119_0_0_FRA	0.4	5.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0
OTT_CRU_100-119_0_0_FRA	0.4	0.0	1.6	0.0	0.0	0.0	0.0	0.0	0.0
OTB_CEP_70_99_0_FRA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OTB_CRU_100-119_0_0_FRA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GNS_DEF_120-219_0_0_IRL	0.0	0.0	0.0	0.0	0.5	0.0	2.7	0.6	0.0
GTR_DEF_>=220_0_FRA	0.0	10.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OTB_DEF_>=120_0_0_IRL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OTB_DEF_70-99_0_0_ESP	0.0	0.0	17.4	0.0	0.0	0.0	0.0	0.0	159.4
OTB_DEF_70-99_0_0_FRA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OTB_MCD_70-99_BEL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OTM_DEF_100-119_0_0_FRA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SDN_DEF_100-119_0_0_FRA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SSC_DEF_100-119_0_0_IRL	0.0	16.6	26.7	0.0	2.0	13.6	0.0	0.0	59.9

Table 4.3. Effort (fishing days) and revenue (€ x 1000) by métier and for years 2017-19, selected métiers and selected ICES divisions. Data were derived from NWW MS dataset.

	Effort			Revenue		
	2017	2018	2019	2017	2018	2019
OTB_DEF_70-99_0_0_FRA	14629	11968	12436	132184	103904	104592
OTT_DEF_100-119_0_0_FRA	12021	12299	10901	86069	86310	80974
OTB_DEF_100-119_0_0_FRA	11860	10218	11652	93947	85162	94562
OTB_DEF_100-119_0_0_IRL	7610	7396	6636	50544	45300	45202
TBB_DEF_70-99_0_0_BEL	3159	2921	2733	51625	52785	54968
OTB_DEF_70-99_0_0_IRL	3152	2288	991	25573	19268	9451
TBB_DEF_70-99_0_0_IRL	2763	3114	2970	17497	18727	18981
OTB_CEP_70_99_0_FRA	2441	2922	1716	28879	35844	21551
OTB_CRU_70-99_0_0_IRL	2217	1038	1071	43598	20109	25711
SSC_DEF_100-119_0_0_IRL	1969	2176	2984	15881	16391	21414
GNS_DEF_120-219_0_0_IRL	1566	1163	1318	14398	11038	16039
OTT_CRU_100-119_0_0_FRA	1203	592	751	8296	3538	5067
OTB_CRU_100-119_0_0_IRL	906	1247	1543	11667	16470	27120
GTR_DEF_>=220_0_FRA	754	737	703	25693	24914	26436
OTB_DEF_>=120_0_0_IRL	318	238	537	2573	2305	3952
OTM_DEF_100-119_0_0_FRA	237	330	1	1609	2164	3
OTB_CRU_100-119_0_0_FRA	116	2	1	548	5	6
OTB_MCD_70-99_BEL	115	210	215	1357	1700	3071
SDN_DEF_100-119_0_0_FRA	97	0	0	911	0	0
OTB_DEF_70-99_0_0_ESP	0	0	32217	0	0	16030

4.2 Persistent hotspots analysis on scientific survey and commercial data

Persistent hotspot areas were mapped by defining hotspots as the ICES rectangle level, or at a more refined grid cell resolution when possible, based on CPUEs (number of individuals caught per unit of effort) greater than the 9th percentile of the CPUE by year. A second step is to obtain an estimation of the Index of Persistence (PI) in each grid cell over the years, defined as:

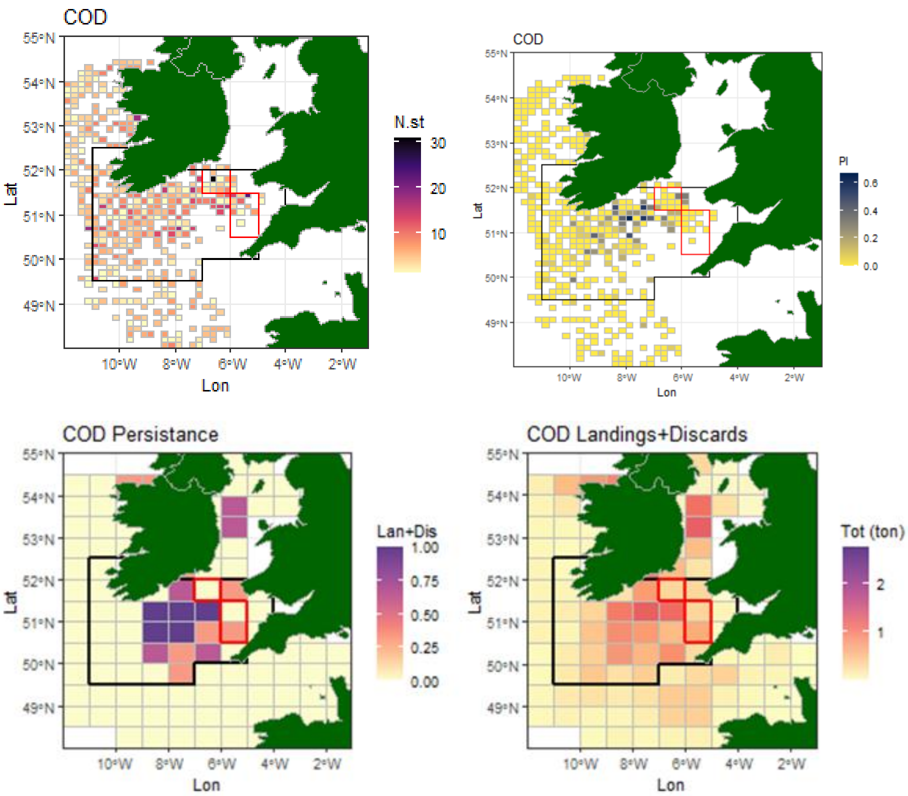
PI = number of hotspots / number of years

The resulting persistency maps by species and length (whole population, juveniles e.g. cod defined as body size less than 35 cm and adults e.g. cod defined as greater than 60 cm) are given in Figures 4.1–4.6, for cod, whiting and haddock.

For haddock and whiting, it was assumed that individuals below MCRS (30 cm and 27 cm, respectively) are juveniles. Based on the information found at *Fishbase*, whiting > 28 cm and haddock > 35 cm are considered adults.

For example, a PI at 0.8 would mean that, on a given area or grid cell, the species would be persisting over 8y out of 10y for a 10y-period)

Working first on scientific trawl surveys DATRAS (EVHOE + IE-IGFS), the EWG 21-18 produced persistency maps to get first insights into the past performance of current closed areas and of possible alternative closed areas and period for the protection of both adults and juveniles of cod by mapping areas of persistence in CPUEs at the finest grid resolution (grid cell size lon =0.25 x lat = 0.125) and using the Minimum Conservation Reference Size (MCRS) as approximate size of sexual maturity, even though it was intended by the regulation to provide incentives to avoid the capture of non-mature specimen. It is worth to note that the grid resolution affects the analysis and it was chosen to ensure that the areas of persistence are not overstated. However, since the scientific survey data are exclusively related to Q4, the EWG 21-18 added further analysis by using commercial data to fill gaps in other seasons. The used CPUEs were deduced from the commercial data consisting of historical landings and discards compiled from the FDI and the NWW MS dataset and distributed over ICES statistical rectangles (Figures 4.1, 4.3 and 4.5).



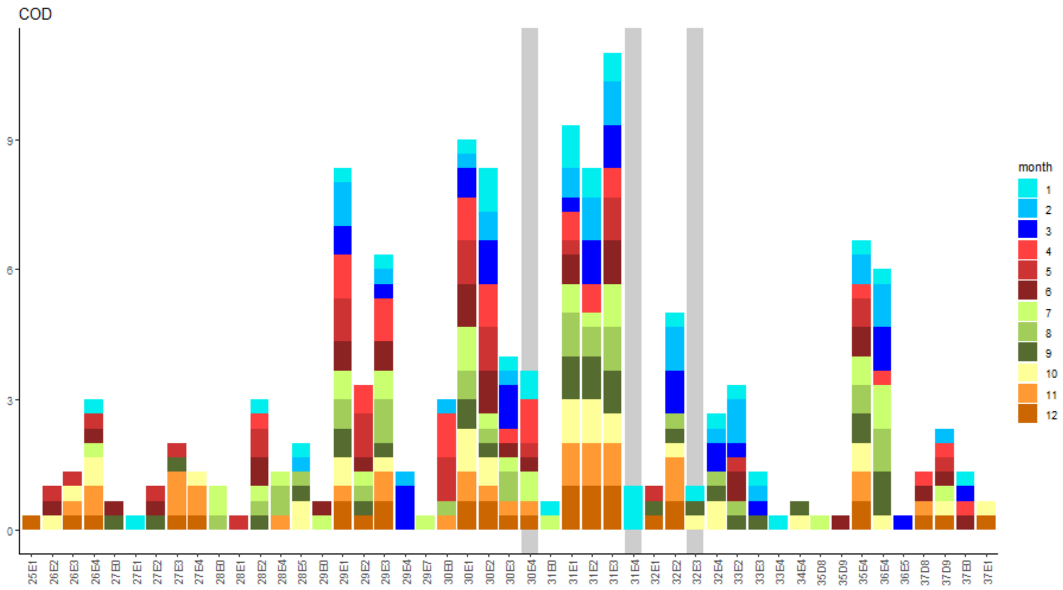


Figure 4.1. Persistent hotspot areas for COD (whole population). Upper plots: based on scientific surveys over quarter Q4 (grid size is 0.25 degrees in lon and 0.125 degrees in lat); medium plots: based on commercial data data over years (grid size fits ICES rectangles as the only spatial resolution available in the commercial dataset); lower plot: Persistency index per rectangle and corresponding months stacked based on commercial data (shaded regions is a visual aid to mark the existing cod closed rectangles ("Trevose closure")). The CSPZ is delineated on the map with a black polygon, the Trevose closure with rectangle in red.

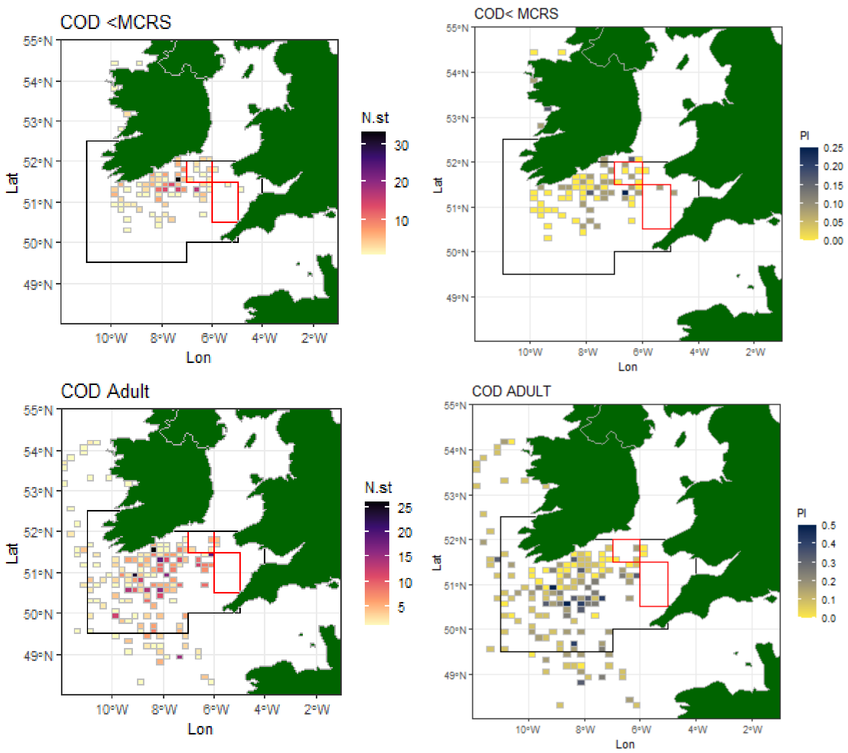


Figure 4.2. Persistent hotspot areas for COD juveniles < 35 cm i.e. the MCRS for Celtic Sea cod) and adults (> 60 cm) based on scientific surveys.

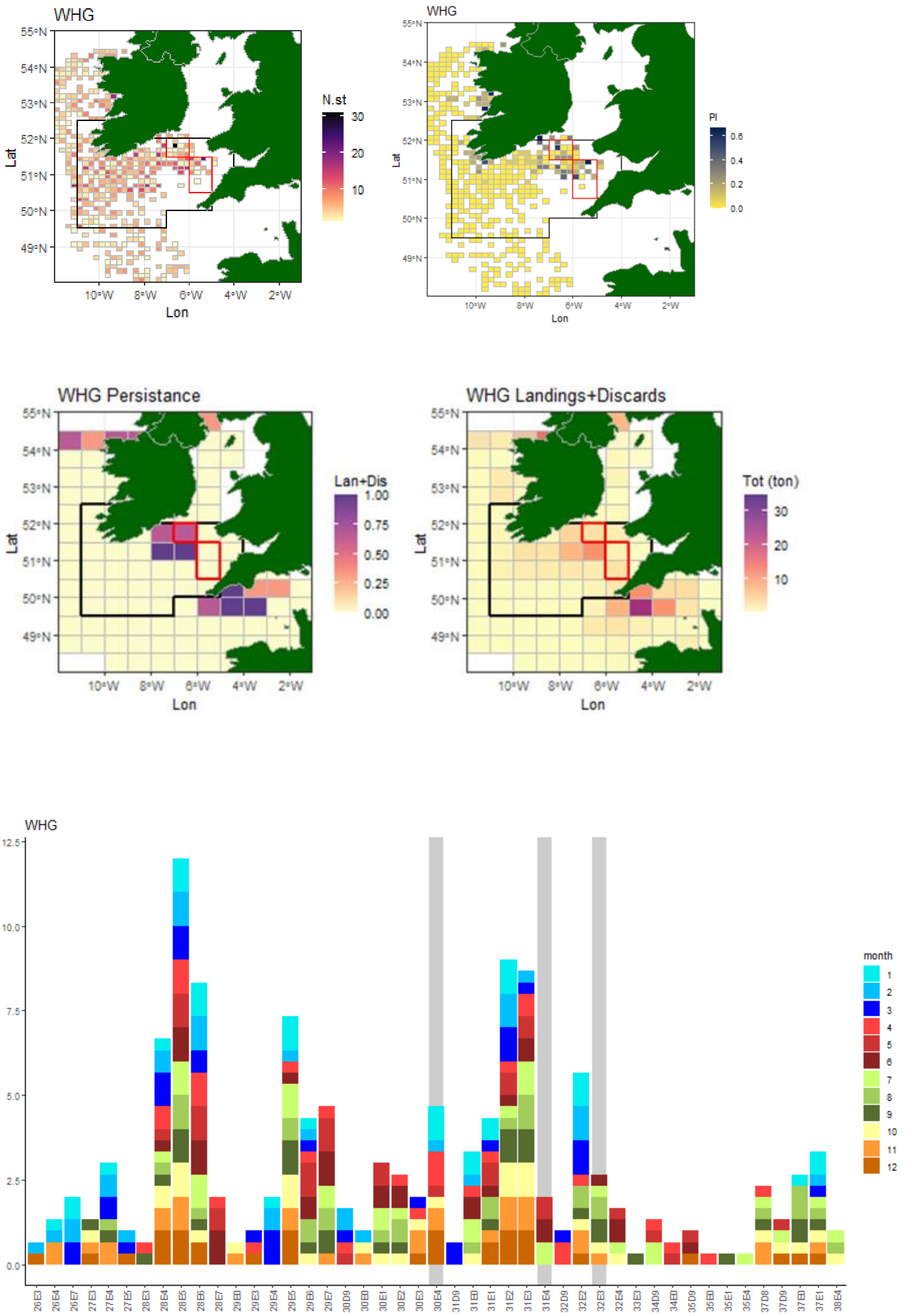


Figure 4.3. Persistent hotspot areas for WHG (whole population. Upper plots: based on scientific surveys over quarter Q4; medium plots: based on commercial data over years; and lower plots: based on commercial data over months (shaded regions represent the existing cod closure rectangles).

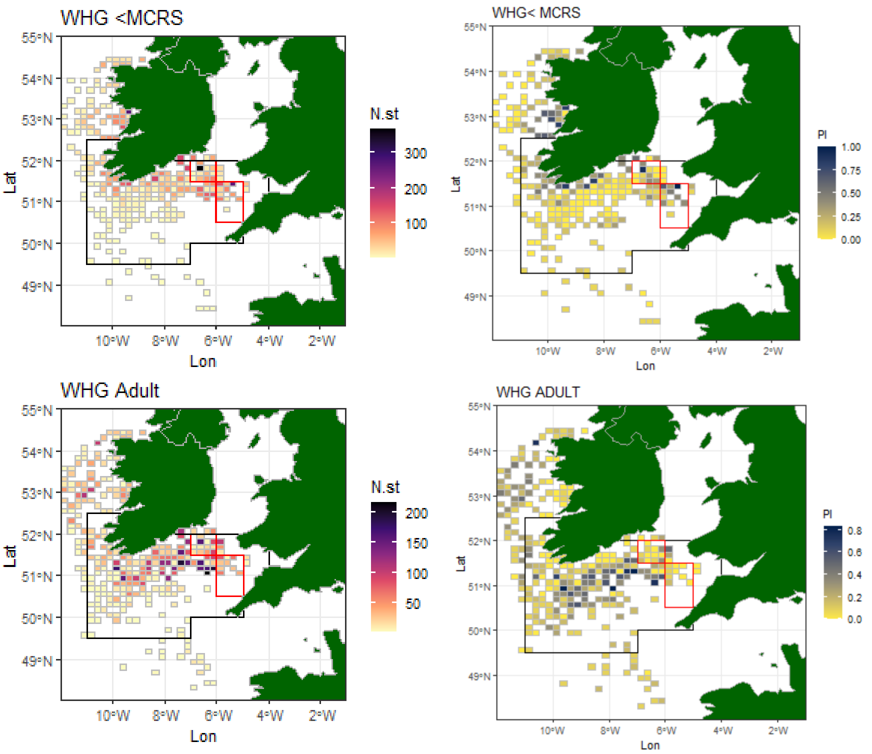
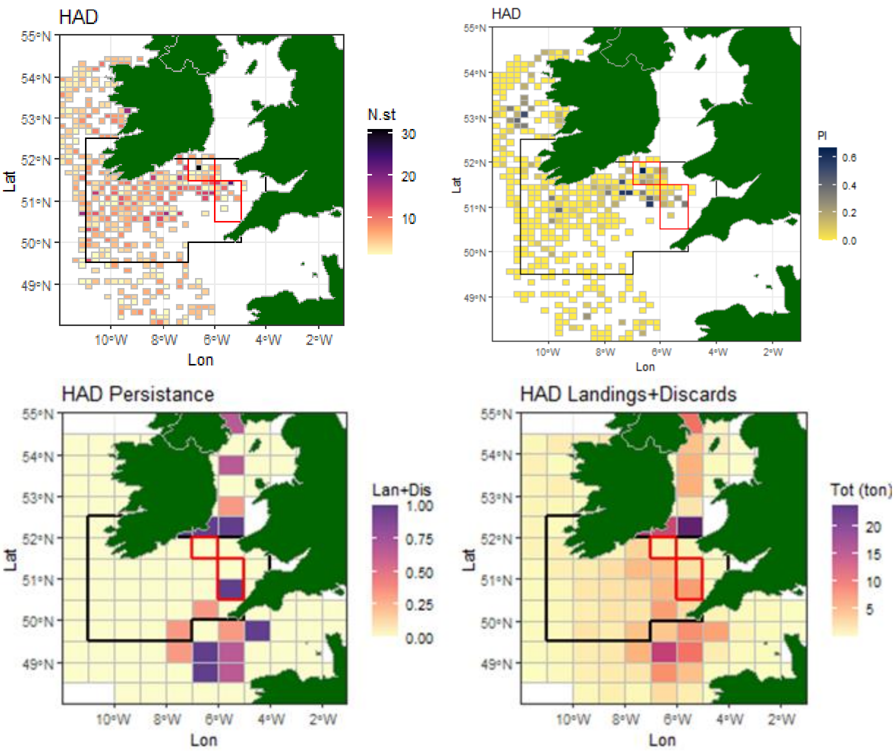


Figure 4.4. Persistent hotspot areas for WHG juveniles (< 27cm i.e. the MCRS for whiting) and adults (> 28cm) from scientific surveys.



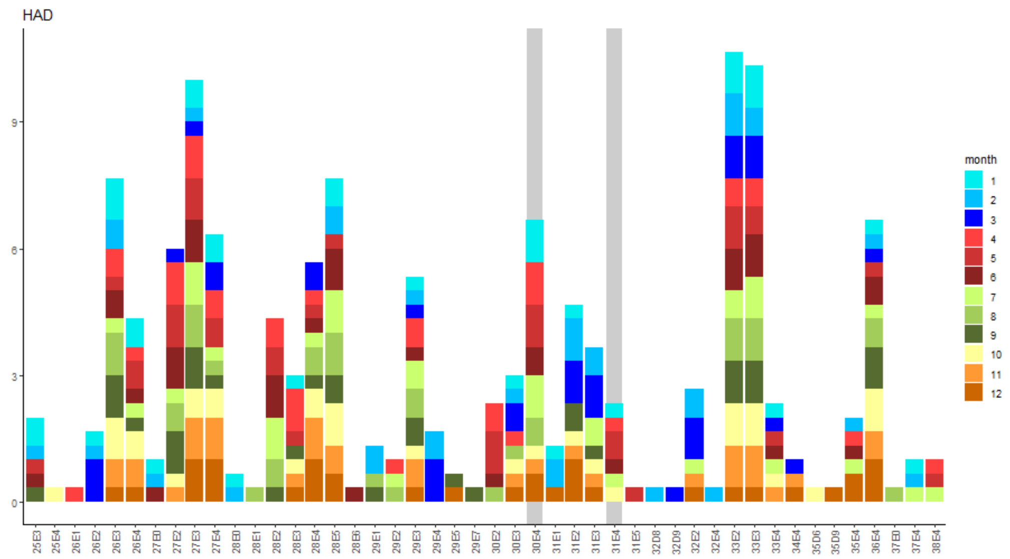


Figure 4.5. Persistent hotspot areas for HAD (whole population). Upper plots: from scientific surveys over quarter Q4; medium plots: based on commercial data over years; and lower plots: based on commercial data over months (shaded regions represent the existing cod closure rectangles).

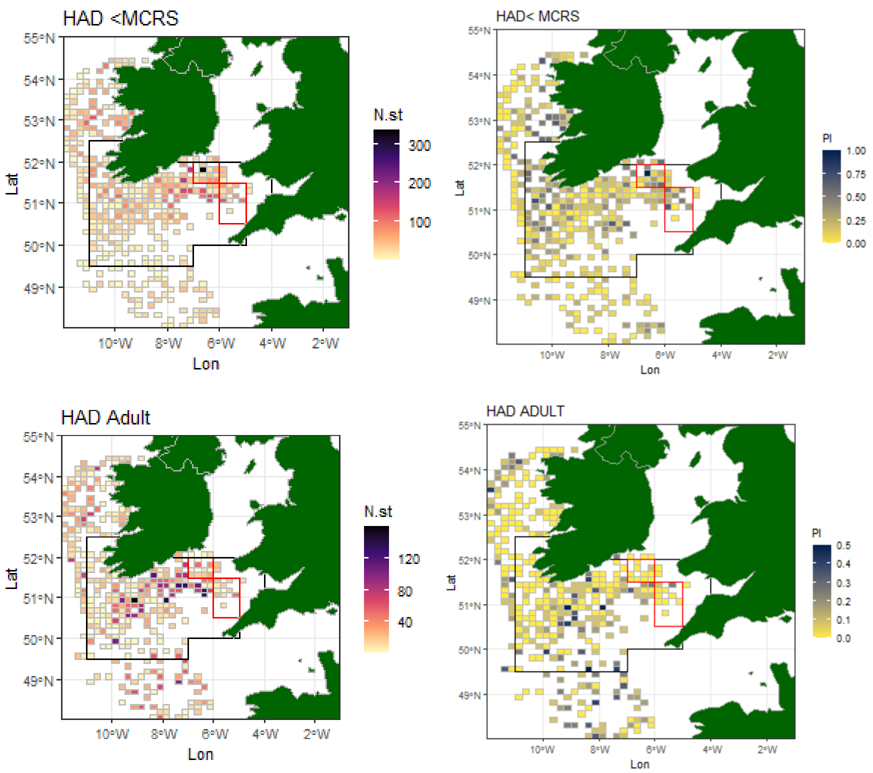


Figure 4.6. Persistent hotspot areas for HAD (juveniles (< 30 cm) and adults (> 35cm) from scientific surveys.

Lastly, the ecological niche additional data were integrated. Final "habitat score" maps were created aggregating at the level of ICES rectangles and taking for each rectangle the mean and the max values between the 3 data sources (survey/commercial indexes of persistence + habitat foraging capacity, Figure 4.7) to make the unit standardized when considering all the sources simultaneously. To compute these "scores", indices of persistence were recomputed for survey data considering only the three years covered by the commercial dataset (2017-2019), while it was chosen the most recent Ecological niche layer among those available (i.e., over 7y for 2010-2016) for which the ecological niche probability was averaged within the ICES rectangles.

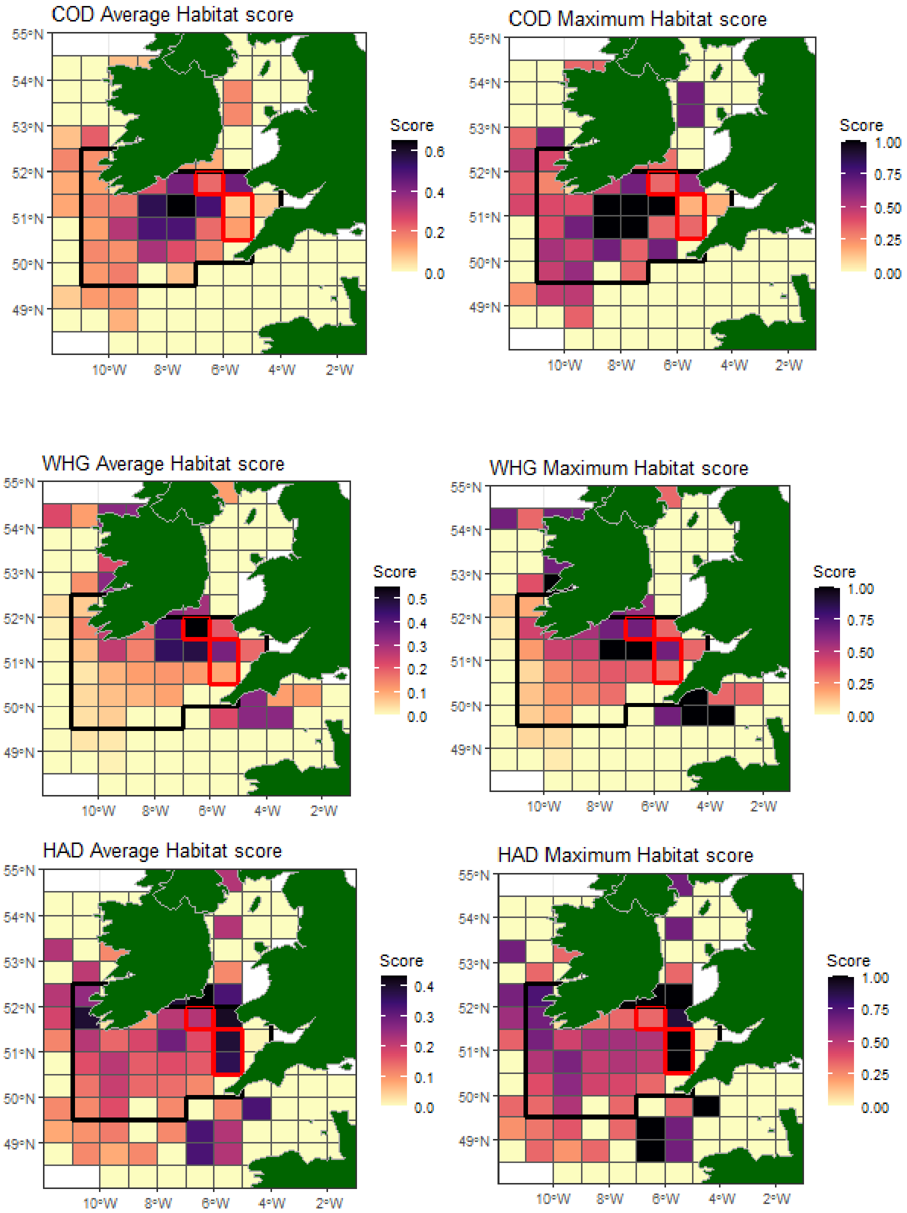


Figure 4.7. "Habitat scores" for COD, WHG and HAD from scientific surveys, commercial data and Habitat foraging capacity (as obtained in Hernvann et al 2020) data.

Persistence maps from the survey and commercial data resulted in being consistent for cod and whiting, except for the area in the south-east CSPZ where no surveys were conducted even though commercial hotspots for whiting and haddock persist. This consistency was evident especially for cod, while it should be investigated for haddock whose persistence near the Trevose closure was mapped only by the survey.

From the hotspot persistency analysis and the following biological "scores" deduced, the EWG 21-18 identified ICES statistical rectangles for possible alternative closure when the maximum "scores" of an ICES rectangle exceeded 0.7, as an arbitrary threshold in lack of more advanced quantitative analysis. The EWG 21-18 identified the best suitable months for the closure as long as the monthly persistence of commercial catch remains relatively high (PI > 0.7).

The outcome of the hotspot persistency analysis, therefore, showed that, by focusing on cod only, from a biological point of view, ICES statistical rectangles 30E1, 30E2, 31E1, 31E2, 31E3 and the neighbouring 29E1 would be the most appropriate candidates for alternative/additional closures within the CSPZ, quite permanently for 31E3 and especially during quarters 3 and 4 for 31E1, 31E2 and 31E3, and during quarter 2 for 30E1 and 29E1.

Additionally, protecting whiting simultaneously to cod could require a more extensive list of ICES rectangles and months. Hence, if the same ICES rectangles were indeed mostly identified to protect whiting, they could apply in combination with ICES rectangles 34E0, 28E5, 28E6 and 29E5 south of the Trevose closed area during winter (for 28E5 and 29E5) and spring (for 25E5, 28E6 and 34E0).

Effects of Trevose cod closure

The existing closed area does not appear to protect persistent areas for cod when deducing those areas from the survey always occurring in year Q4. However, a persistent area for whiting could coincide within the specific ICES rectangles of the Trevose closure for that Q4, and eventually haddock. Due to the limited information available for other seasons in the scientific survey, or before 2017 in the commercial data, it was impossible to evaluate the efficiency and economic impact of such a historical measure.

4.3 Standardizing commercial landing, discard, catch and revenue data

For each of the three considered species, a landing, discard and catch rate (lpue, dpue, cpue) was calculated by dividing the observed landings, discards and catches by its associating fishing effort. Likewise, a revenue rate (rpue) was obtained by dividing the observed total landed value by the fishing effort. Next, the response variables denoted as Y (lpue, dpue, cpue and rpue) were standardized using the following linear regression model:

$$log\ (Y) \sim \beta_0 + \beta_{1_y} \times\ year_y\ +\ \beta_{2_m} \times\ métier_m\ +\ \beta_{3_{t,s}}\ \times\ month_t\ \times\ ICESsquare_s\ +\ \varepsilon,$$

in which β_0 represents the model intercept, the coefficients of β_{1_y} represent the year effects (y ∈ [2017;2019]), the coefficients of β_{2_m} account for the country-specific métier effects (m), and $\beta_{3_{t,s}}$ represents a spatio-temporal effect for the different combinations of ICES statistical rectangles and months included in the data. The error term (ε) is assumed to follow a random distribution.

This standardization helps to reduce the effect of potential outliers and, in this case, the β_3 parameters can be seen as the average spatio-temporal patterns over the last 3 years. Therefore, the spatio-temporal closures are defined for the "average" spatio-temporal patterns of the last 3 years.

Following model fitting, predictions were made for the variables of interest across all the different levels of métiers and countries, and spatio-temporal combinations occurring in the data. Only the year effect was kept constant at the final year of the analysis (2019). By using model predictions, the identified spatio-temporal closures are assumed to be more robust against potential outliers, and are defined for the "average" spatio-temporal pattern underlying the fishery of the last 3 years.

The resulting lpue maps and revenue maps (predicted rpue x fishing effort) by métier are given in Figures 1-21 of Annex 2.

4.4 Identifying candidates for closed areas

To identify suitable areas for spatio-temporal closures with consideration for the trade-off between efficiency and the economic short term impact, the EWG 21-18 designed a new linear programming approach to investigate how best to reduce the unwanted catches along with a gradient of reduction expressed as a fraction of the total catch. Are investigated combinations of the month and ICES Statistical rectangle that would reduce the unwanted catch while minimizing the loss of total revenue of the fleet. Hereto, the following linear programming formulation with binary decision variables was defined:

Maximize: $Revenue = \sum_{t,s} \quad x_{t,s}(\sum_m \quad Revenue_{m,t,s})$

$$Subject\ to: \sum_{t,s} \quad x_{t,s}\left(\sum_m \quad Catch\_sp_{m,t,s}\right) \leq scenario_i \sum_{t,s} \quad \left(\sum_m \quad Catch\_sp_{m,t,s}\right)$$

Were $x_{t,s}$ are binary decision variables by month (*t*) and ICES statistical rectangle (*s*), the subscript *m* refers to the métier level, and the scenario takes a value between 0 and 1, as such defining how much the catch should be reduced. In this current version of the model formulation, spatial effort displacement of closed fishing areas to open fishing areas is not accounted for.

The analysis was performed for four species scenarios: cod, whiting, haddock, and cod and whiting simultaneously. For each of those species scenarios, the simulation calculates the outcome of targeted catch reduction (relative to the status quo catch) with a multiplier that ranges from 1 to 0 with steps of 0.01 (i.e. increment of 1% reduction in total catch). For cod, the tested ICES rectangles for closure were only the ones belonging to the CSPZ.

Optimal gradient for spatio-temporal closures limiting short term losses in fishing opportunities

By the nature of the model formulation, reducing catches of specific species (combinations) through spatio-temporal closures leads to short-term losses for the fishery in the Celtic Sea (Figure 4.8). Nevertheless, the curves obtained along the reduction gradient demonstrate that the revenue losses are not reduced as fast as the total catch on the tested species. In particular, small reductions of catch levels, associated with a limited number of spatio-temporal closures, do not associate with large revenue losses, as not all métiers are affected by such reduction measures. However, the EWG 21-18 observes that when the targeted catch reductions are becoming more and more limiting along with more and more closed rectangles and months, the reduction in revenue losses declines abruptly.

The outcome of the optimisation procedure shows that there are specific to the tested species:

Whiting

The search for reducing catch applied to whiting showed that a smaller short-term impact on revenue could be obtained than haddock and even more to cod. For example, optimising placement and period for closure for a 40% reduction in whiting catch would imply a 10% reduction in revenue per unit of effort. A lower impact of reducing whiting shows that areas with the largest catch of whiting are associated with lower economic returns. Hence, the optimisation/ordering model first selected the cells with relative low historical revenue compared to the relative catches of whiting.

Haddock

The shape of the curve shows that a reduction of the catches is harder to achieve for haddock without impacting the short-term economic impact. Hence, for example, a 40% reduction in haddock catch would imply a 19% reduction in revenue per unit of effort. This more extensive effect than whiting results from the fact that haddock catches distribute more evenly spatially and throughout the year.

Cod

EWG 21-18 searched for an optimal combination of ICES rectangles and months when designing a closure to protect cod with reduced catches while minimising the effect on short term revenue. This search showed that the economic return would decrease more slowly along with a more significant fraction of closed areas than the amount of unwanted catch (a 40% reduction would imply a 20% reduction in short-term revenue per unit of effort). However, this decrease in revenue per unit of effort is anticipated larger than from other species, i.e. haddock and whiting, especially because cod catches are associated with areas and fisheries, giving a higher economic return. Besides this effect, for cod, the solution space of the model (for complying combinations of ICES rectangles and months) was deliberately smaller, as the EWG 21-18 constrained the search to only trigger ICES rectangle that belongs to the CSPZ, which is shown to only be achieved with higher revenue losses.

Cod & whiting

Putting higher constraints in the optimisation procedure mechanically reduces the space for a possible combination of ICES rectangles and months that would comply with these constraints. It is the case when catch reductions on more than one species are the objective. However, setting the objective to reduce both on the cod and the whiting catch simultaneously would reduce the loss on short-term economic return to a lesser extent (e.g. 17% if 40% catch reduction is the target) than cod isolated, splitting the effect of the tested closures on different fisheries.

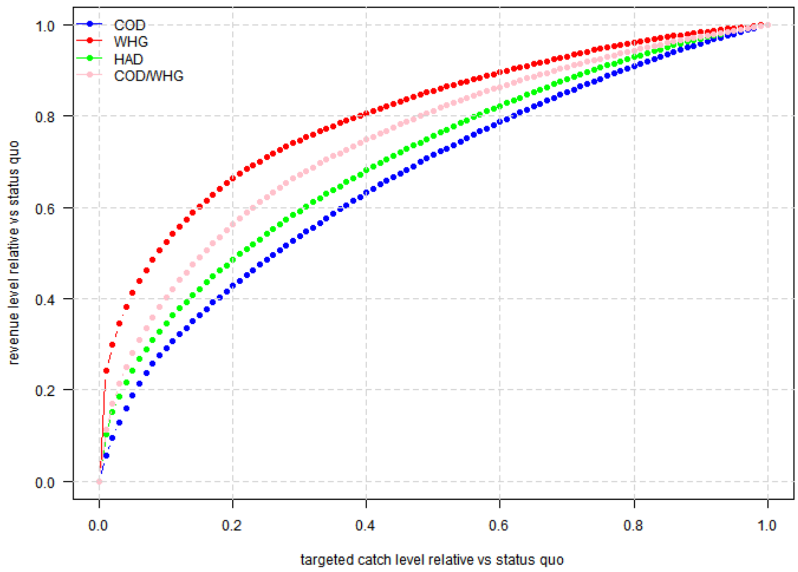


Figure 4.8. Reduction in short term revenue along with a reduction of catches for COD, WHG and HAD, or a combination of COD & WHG. The point coordinate (1,1) defines the starting point with no reduction applied (i.e. historically observed economic return), while the point (0,0) defines the point where the fishing is supposed to be entirely closed (i.e. no economic return possible). The axes are standardized to 1 to enable the comparison across species.

Behind each of the dots shown in Figure 4.8, a specific closure is identified as a combination of ICES rectangles and months that comply with the optimisation model formulation. Figure 15 shows an example of a 50% reduction in cod catch. Other closures associated with each of the species scenarios and catch reduction scenarios (by 10% increments) are provided in Annex 3.

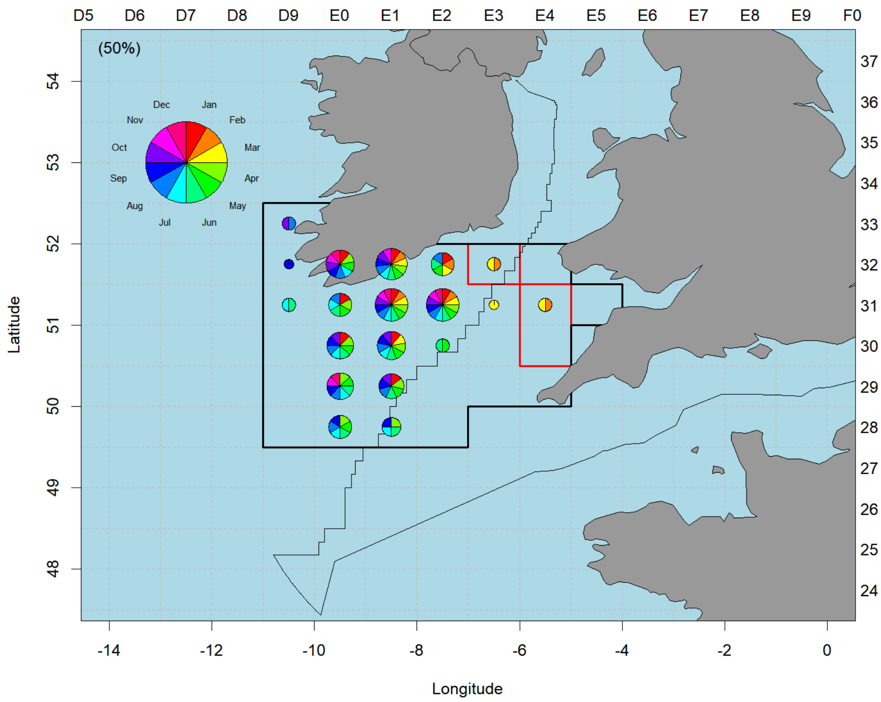


Figure 4.9. Spatio-temporal closure to reduce the catch level of cod by 50% compared to the status quo catch level. In this Figure, the size of the pies in the ICES rectangles indicate how frequent an ICES statistical rectangle is closed throughout the year, while the colors in the pies refer to the specific closure months. The black and red boxes indicate the CSPZ and Trevose box closures, respectively. The EEZ limit between the UK and EU is also shown.

Métier specific trade-offs are presented in Figures 4.10 to 4.13. EWG 21-18 obtained the métier detailed information by calculating the impact of the optimised catch reduction overall on the short-term historical revenue of each fleet-segment for each identified closures. As such, the métier specific impacts do not reflect scenarios that have been optimized at the métier level.

The outcomes show that combining ICES rectangles and months within the CSPZ for reducing cod catches would mainly affect the Irish SSC, Irish TBB and French OTB_DEF_100-119 métiers. In contrast, other fleets, including the Belgium beam trawl fleet and the French OTB_DEF_70-99 métiers, are hardly affected by the closures as long as catch reductions do not exceed 50% targeted. The EWG 21-18 observes that the same fleets are affected when implementing the closures to reduce the whiting catches. However, the fleets that would experience a small impact on short-term revenue (French OTT métiers and Spanish OTB fleet) differ from those identified for the cod scenario. For the haddock scenarios, only one type of fleet, the Irish OTB_CRU métiers, is marginally impacted in terms of revenues, showing this fleet's minimal dependence on haddock catch. The most substantial métier-specific effects appear when catch reductions are searched on both cod and whiting simultaneously. In particular, The Irish SSC and TBB métiers have the potential for short term revenue losses exceeding 50% when a reduction of cod and whiting catches of 30% would be the management target, illustrating their very high dependency on both stocks.

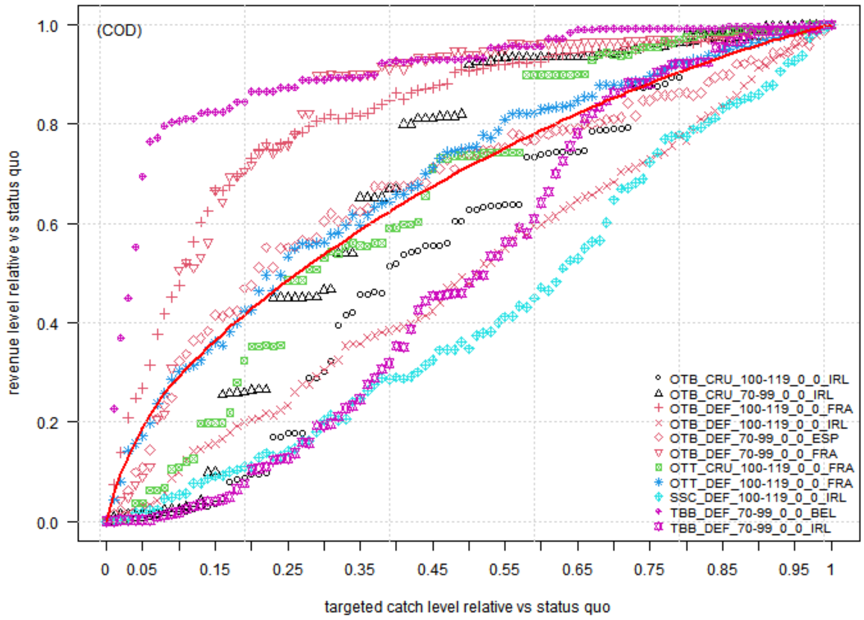


Figure 4.10. Métier specific impacts on short term revenues for different targeted catch reduction scenarios (i.e. increment of 1% reduction) of cod. The solid red line represents the overall impact on the fishery as shown in Figure pooling all segments.

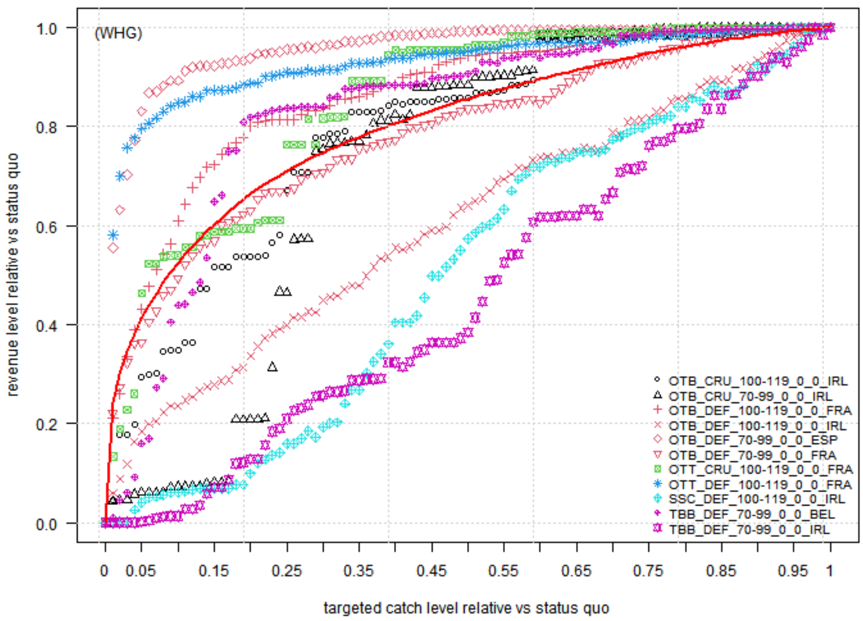


Figure 4.11. Métier specific impacts on revenues for different targeted catch scenarios of whiting.

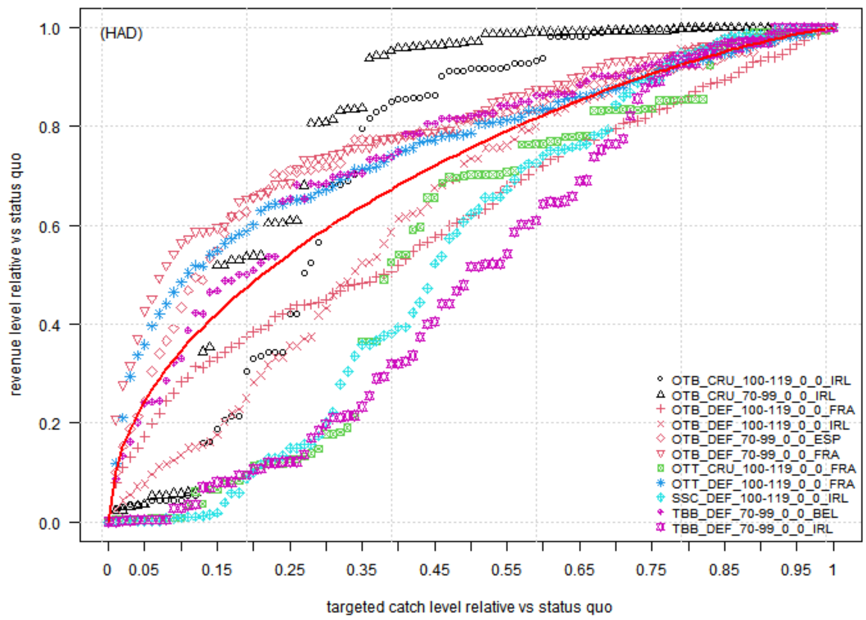


Figure 4.12. Métier specific impacts on revenues for different targeted catch scenarios of haddock.

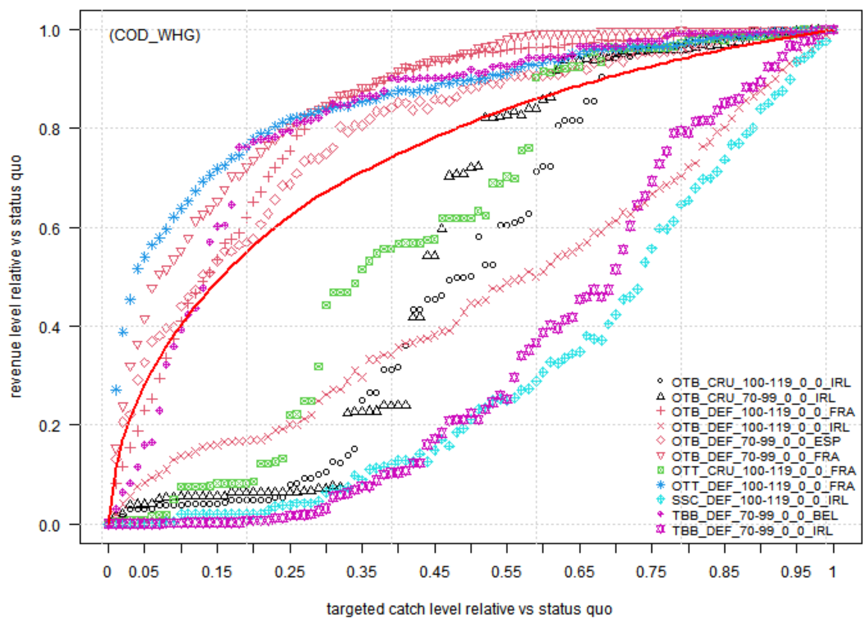
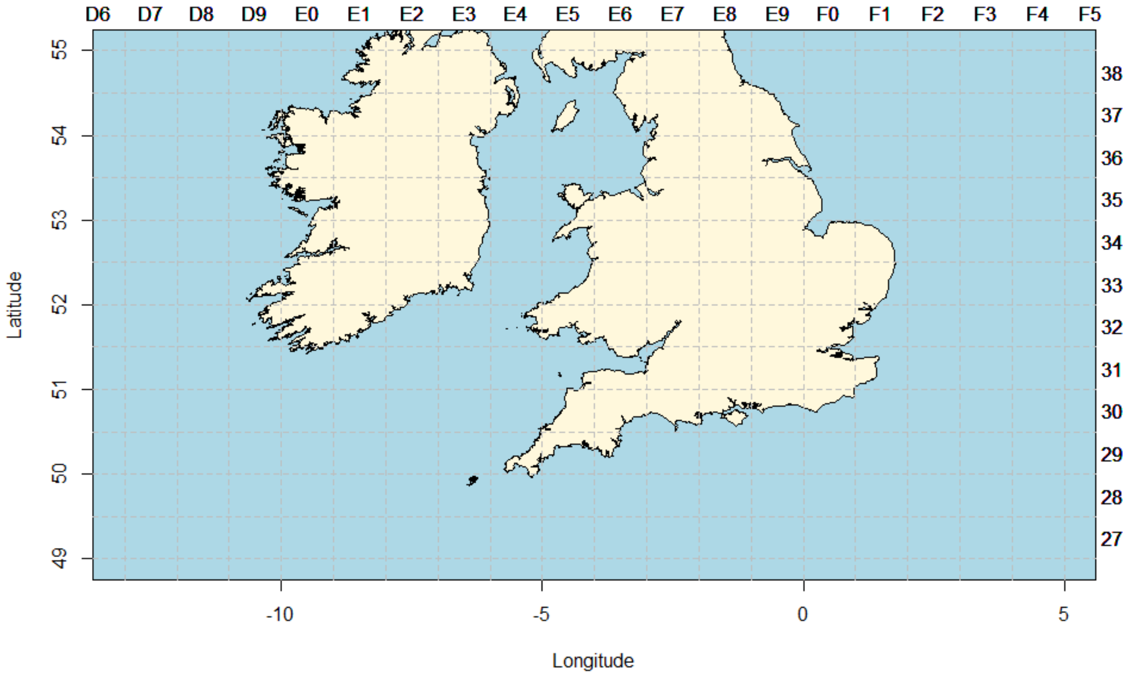


Figure 4.13. Métier specific impacts on revenues for different targeted catch scenarios of cod and whiting simultaneously.

As a summary, an overview of the relative frequency of closures by ICES statistical rectangle and months across all species scenarios is given in Table 4.4 and Figure 4.14 and 4.15. Rectangle 31E1 appears to be the best candidate to protect both cod and whiting, and 30E1 and 32E1 to a lesser extent. It is also shown that the second half of the year is the best period for closing based on the cod and whiting simultaneously.

Table 4.4. Relative frequency of ICES rectangles and average month (a value between 1 and 12 giving the most frequent month per rectangle, from averaging with a "circular mean"), identified as potential areas for closures to reduce catches of cod, whiting and haddock across all catch reduction scenarios. ICES rectangles are ordered in the table from the most frequent to the least frequent rectangle on cod in the selection driven by the optimization procedure. The relative frequency greater than 0.75 are marked in bold. "NA" stands for Non-Assigned. ICES rectangles are identified in the map.



	COD		WHG		HAD	
ICES rect	relative freq	avg month	relative freq	avg month	relative freq	avg month
31E1	**1.00**	7.21	**0.83**	5.68	0.69	1.83
30E1	**0.79**	5.42	0.43	6.43	0.48	2.76
32E1	**0.77**	5.14	**0.75**	6.09	0.53	2.61
31E2	**0.75**	0.65	**0.95**	10.67	0.74	0.79
30E0	0.71	6.60	0.59	7.53	0.65	11.37
29E0	0.71	6.48	0.12	9.20	0.72	0.89
32E0	0.67	7.91	0.34	11.99	0.49	9.77
29E1	0.59	6.31	0.08	8.53	0.32	9.01
32E2	0.58	2.94	**0.88**	8.54	0.62	3.04

28E0	0.56	6.45	0.03	8.57	0.61	1.48
31E0	0.51	4.61	0.55	6.43	0.34	2.34
28E1	0.45	5.65	0.02	7.43	0.77	6.49
31E3	0.39	3.11	0.57	8.10	0.36	1.95
30E2	0.37	4.94	0.40	7.79	0.43	3.40
32E3	0.30	2.42	0.39	7.48	0.23	3.68
31D9	0.29	6.15	0.21	3.69	0.29	2.71
29E2	0.27	4.50	0.13	6.72	0.39	6.93
30E3	0.25	3.18	0.32	10.54	0.65	2.66
31E4	0.21	2.08	0.27	2.86	0.34	3.04
32D9	0.19	6.67	0.25	4.23	0.27	3.94
33D9	0.18	7.98	0.22	6.94	0.18	6.98
30D9	0.16	7.68	0.04	1.76	0.23	11.36
29E3	0.13	3.73	0.12	1.17	0.63	0.70
32E4	0.12	4.32	0.24	6.52	0.17	4.58
28E2	0.10	4.09	0.03	5.85	0.57	5.79
29D9	0.10	7.45	0.02	2.80	0.11	9.85
28D9	0.10	6.24	0.02	11.50	0.09	7.79
29E4	0.05	3.87	0.24	0.90	0.41	3.79
30E4	0.04	2.70	0.13	0.95	0.33	5.36
31E5	0.03	6.41	0.06	5.15	0.20	5.98
25E0	NA	NA	0.01	5.93	0.04	3.41
25E1	NA	NA	0.01	5.93	0.04	11.77
25E2	NA	NA	0.01	5.93	0.03	7.14
25E3	NA	NA	0.01	5.93	0.20	7.14
25E4	NA	NA	0.02	5.50	0.06	5.23

25E5	NA	NA	0.08	1.92	0.04	11.73
26D9	NA	NA	0.01	5.93	0.02	0.76
26E0	NA	NA	0.01	5.93	0.11	0.23
26E1	NA	NA	0.01	5.93	0.12	3.47
26E2	NA	NA	0.01	5.93	0.28	6.66
26E3	NA	NA	0.02	9.61	0.69	7.94
26E4	NA	NA	0.06	1.87	0.43	6.02
26E5	NA	NA	0.11	2.43	0.06	10.64
26E6	NA	NA	0.26	6.19	0.28	6.90
26E7	NA	NA	0.20	1.71	0.49	10.52
27D8	NA	NA	0.01	5.93	0.01	10.00
27D9	NA	NA	0.01	5.93	0.04	4.12
27E0	NA	NA	0.01	5.93	0.28	1.81
27E1	NA	NA	0.01	5.93	0.62	4.49
27E2	NA	NA	0.02	5.85	0.73	6.12
27E3	NA	NA	0.14	5.28	1.00	7.88
27E4	NA	NA	0.20	1.26	0.63	7.79
27E5	NA	NA	0.17	1.41	0.09	8.53
27E6	NA	NA	0.11	2.11	0.04	9.82
27E7	NA	NA	0.13	2.15	0.05	9.61
28D8	NA	NA	0.06	9.75	0.03	9.57
28E3	NA	NA	0.13	7.33	0.70	9.39
28E4	NA	NA	0.49	0.53	0.48	9.47
28E5	NA	NA	0.64	2.14	0.27	7.44
28E6	NA	NA	0.58	3.31	0.04	6.49
28E7	NA	NA	0.20	5.19	0.04	7.52

29D8	NA	NA	0.02	0.50	0.01	2.50
29E5	NA	NA	1.00	6.52	0.25	5.34
29E6	NA	NA	0.39	5.08	0.03	5.75
29E7	NA	NA	0.35	6.14	0.08	8.03
30D8	NA	NA	0.01	5.93	0.02	8.45
31D8	NA	NA	0.01	2.50	0.08	11.13
32D8	NA	NA	0.04	4.51	0.11	1.91
33D8	NA	NA	0.04	7.47	0.10	7.58

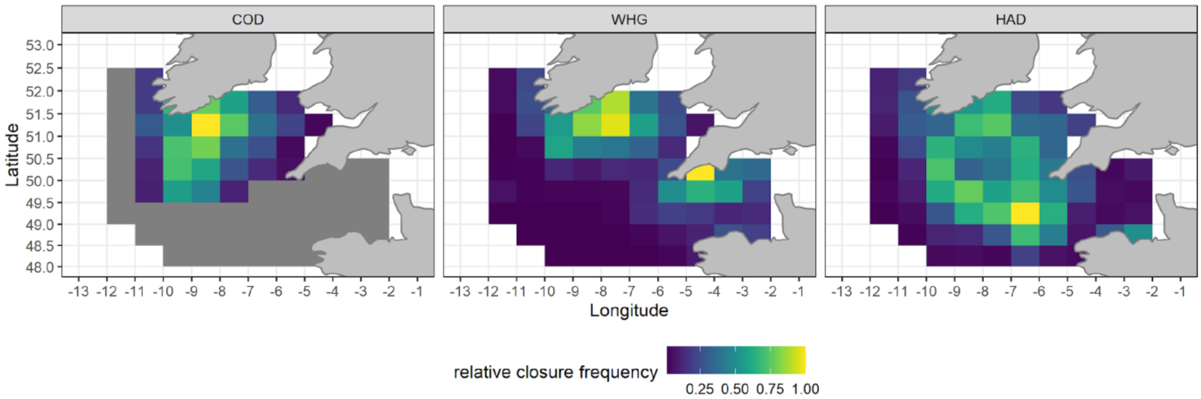


Figure 4.14. Relative frequency of identified spatio-temporal closures across all scenarios for each of the single species scenarios.

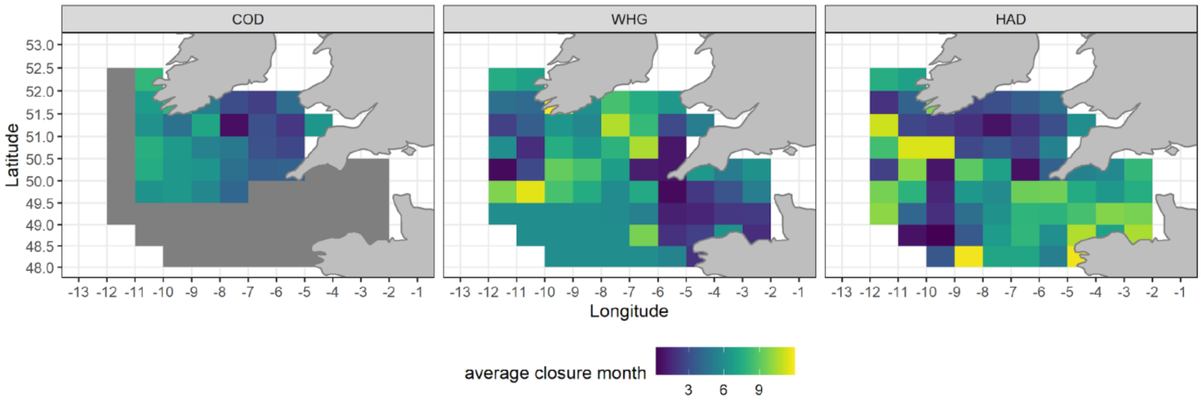


Figure 4.15. Average closure month (circular mean) by ICES statistical rectangle across all catch reduction scenarios.

4.5 Correlation between identified spatio-temporal closures by the optimisation procedure versus hotspot persistence analysis

To integrate the additional evidence gathered in the present work, the EWG 21-18 has compared the identified closed areas and period with the persistence values of cod, whiting and haddock in the other ICES statistical rectangles obtained earlier. EWG 21-18 did this by calculating the statistical correlation between the ICES rectangle-specific frequency for closing across all catch reduction scenarios and the persistence values calculated for each ICES statistical rectangle using different data sources as described in section 4.1. Positive correlations imply that both the economic trade-off analysis and the biological mechanisms support the identified ICES rectangles for closures. Positive correlations were found for all combinations of persistence metrics and species scenarios (Table 4.5). An absence of correlation was found only for the persistence values based on the survey data (whiting and haddock), Ecospace data (haddock), and the identified closures of whiting and haddock. EWG 21-18 noted that the correlation between the persistence metrics based on the Ecospace data and the identified closures for cod seems to reduce the catches of juvenile cod.

Table 4.5. Correlation (from -1 to 1, with -1 expressing a perfect negative correlation, 1 a perfect positive correlation, and 0 an absence of correlation) between the persistence metrics by ICES statistical rectangle and the frequency of the closed areas and periods identified in the optimization analysis. Correlations are defined for all the biological data sources.

	With persistence based on survey	With persistence based on commercial data	With persistence based on both survey and commercial data	With persistence based on ecospace data layer	With persistence based on ecospace data layer for juv.	With persistence based on ecospace data layer for adults
cod	0.54	0.37	0.49	NA	0.47	0.27
whiting	0.1	0.7	0.69	0.55	NA	NA
haddock	-0.03	0.38	0.32	0.13	NA	NA

Listing the characteristics of the selected ICES rectangles (Table 4.6) shows that the selection overlaps, stressing again that both the economic trade-off analysis and the biological mechanisms support the identified ICES rectangles for closures. It is also shown that fisheries behind each rectangle are not the same, and therefore, the closure of each of these rectangles or a subset of them will not impact the same fishing agents.

Table 4.6. Characteristics in ICES rectangles selected by either the persistence hotspot analysis (30E1, 30E2, 31E1, 31E2, 31E3, and 29E1) or the optimization procedure (30E1, 31E1, 31E2, and 32E1), or both. First two percent columns show the contribution of the ICES rectangle to the total landed kg for COD and WHG. Other columns show the percent decomposition of landed kg per species in a given rectangle for each selected ICES rectangle.

ICES Rect.	COD % ALL FISHERIES	WHG % ALL FISHERIES	% Value ALL species	HKE %	MNZ %	WHG %	LEZ %	ANF %	MEG %	HAD %	NEP %	COD %	WIT %	EOI %	RJO %	POK %	SYC %	PLE %	RAJ %	POL %	JOD %	LEM %	MUL %
29E1	4.11	0.10	1.01	7.5	8.8	0.7	9.9	10.8	6.2	6.4	24.7	4.2	3.3	0.4	1.2	1	1.2	0.6	0.5	0.9	1	0.3	0
30E0	3.83	1.42	0.72	15.5	10.5	10.3	9	7.7	6.8	6	4.3	3.9	3.5	2.6	1.6	1.5	1.3	1.1	1.1	1	0.9	0.9	0.9
30E1	3.54	1.29	0.94	13.3	13.6	7.9	6.9	6.2	6.7	6.9	14	3.1	4.5	0	0	0.4	3	0.7	0.8	0.6	1	0.8	0.6
31E0	3.82	1.47	0.78	11.3	6.7	11.2	9.2	13.4	2.4	6.4	4.7	4.1	3.7	0.2	0.2	1.7	0.6	0.8	4.3	1.8	0.9	2.7	0.1
31E1	6.00	3.13	0.97	10.4	4.5	16.1	9	8.9	0.7	7.6	1.4	4.3	1.9	0	0	2.1	1.1	0.7	2.7	2.4	0.5	2.5	0.3
31E2	4.32	5.75	2.25	2.3	2.9	18.3	3.6	5.5	1.1	4.2	40.9	1.9	1.2	0	0	1	1.6	0.2	1.3	1.3	0.7	0.8	0.1
32E1	0.80	0.50	0.32	6.5	5.7	10.1	7	9.5	1.4	4.3	8.3	2.3	3.4	0	0	1.9	1.5	0.9	5.7	3.9	1.1	2.8	0.6

4.6 Accounting for effort reallocation

The optimization model used to identify spatio-temporal closures aiming to reduce the catches of cod, whiting, and haddock does not account for a displacement of fishing effort that would, however be likely when fishing agents search for maintaining their expected level of economic return. Therefore the EWG 21-18 also investigated how the effect of reallocation from the closed fishing grounds to the still opened fishing grounds would affect the effectiveness of the proposed closures. The effort loss by métier and month was calculated and reallocated to the remaining open fishing grounds for that métier during the same month, assuming the overall seasonal allocation to keep the same. This also avoids assuming unrealistic behaviour where fleets would spend all their effort during one month, which is physically bounded.

After displacing fishing effort to the opened areas, the catches and revenues are then calculated by multiplying the augmented effort to the historical CPUEs, and RPUEs values observed on these areas. Such a calculation assumes the absence of a relationship between catch rates and effort deployed on zones known as the "hyperstability" effect. This assumption on hyperstability is likely to hold, up to the point that a local depletion on particular fishing grounds where the effort would redirect and concentrate would not affect technical interactions between fleets or the underlying exploited stock vulnerabilities, and the efficiency of the fleet to maintain their catch on possibly unknown fishing grounds. Hence, the result of this analysis is likely to overestimate the catches when accounting for fishing effort reallocation when the reduction objective is high.

On the other hand, not accounting for the effort displacement effect is also likely to overestimate the impact of a reduction in catch to protect certain species (Figure 4.16), and especially for cod (e.g. by ca. 22% less reduction than expected if a reduction by 40% is the objective). The dashed grey line shows the targeted catch. Hence the further the line is above the dashed grey line, the less effective the spatio-temporal closure when fishing effort reallocation is considered.

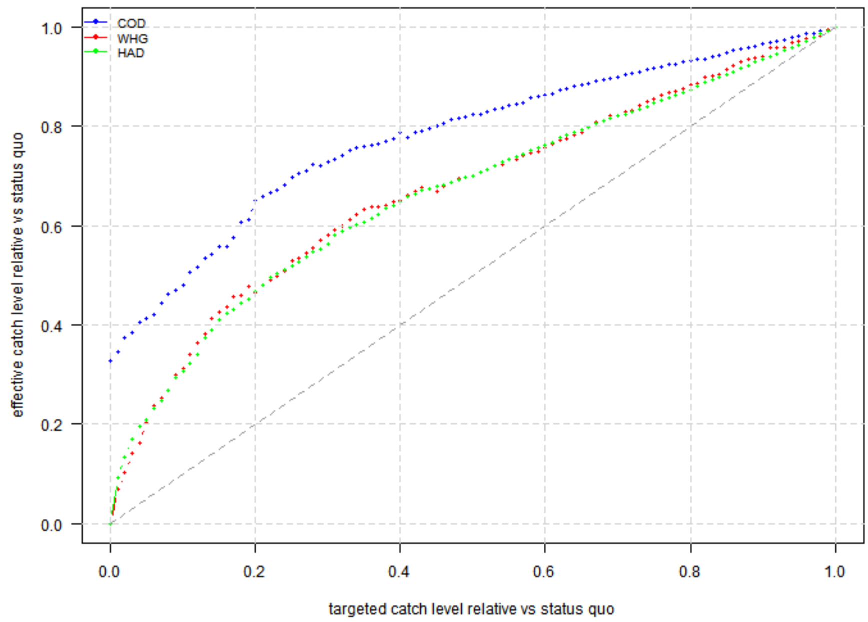


Figure 4.16. Deviation of the potentially realised catches from the targeted level of reduction of catches for COD, WHG or HAD induced by the spatial fishing effort displacement. The dashed grey line shows the targeted catch.

4.7 A dynamic bio-economic model to simulate effort displacement effects

Beyond identifying possible short-term effects obtained from static views and measure of fraction impacted based on historical data, bio-economic models that account for long-term and feedback effects and the projection of the replenishment and recovery are needed. As preparatory work for this EWG, a scenario testing the bio-economic impact of spatial plans on Celtic Sea fisheries was conditioned using the DISPLACE agent-based modelling platform (Bastardie et al., 2019). This model follows a size-spectrum modelling approach accounting for the potential predation effect among species when fishing pressure is displaced. This approach made this model particularly suitable for the evaluation of spatial management measures.

The model simulates short- and medium-term impacts, avoiding the aggregation of individual fishing operations and detailing the spatial and temporal dimension for particular fishing activities, local communities or national fleets. A detailed description of the model methodology, input data, and model results are provided in Annex 4.

The DISPLACE model conditioned to the Celtic Sea concluded that the main problem when avoiding choke species in mixed fisheries and landing obligation context is the expected losses in other marketable catch. The losses' value depends on the fleet and the year but is likely much less than suffering an early choke if no avoidance is attempted. Hence the model showed that such deliberate avoidance of areas where the risk for encountering a "choke species" is high is indeed beneficial for exploited stocks and, therefore, for the long-term profitability of the fleet. It is also seen that complementary management measures to the landing obligation, such as closed areas (here to protect cod redirecting effort on the highest fish density areas), can mitigate the issue by encouraging fishers to visit and fish areas where the fishing impact will be lower. As shown by our simulation exercise, such a minimised impact would most likely combine to long-term benefit regarding both the biological and economic aspects in the demersal Celtic Sea fisheries. Incentivizing or forcing fishing vessels to focus on the more productive areas is also a way to limit a compensation effect that would arise from a greater deployed effort by the fleet in an attempt to balance out the short-term loss that a spatial displacement of their traditional activities could induce (Figure 4.17).

Although additional modelling parameterisation and calibration is needed to implement this model in the Celtic Sea fully, it is considered an appropriate dynamic approach for evaluating spatial measures in the Celtic Sea. It was also not possible to re-run the simulation study during the EWG as the model would have required some time to properly input the candidates ICES rectangles and months for closed areas identified in the ToR2 evaluation.

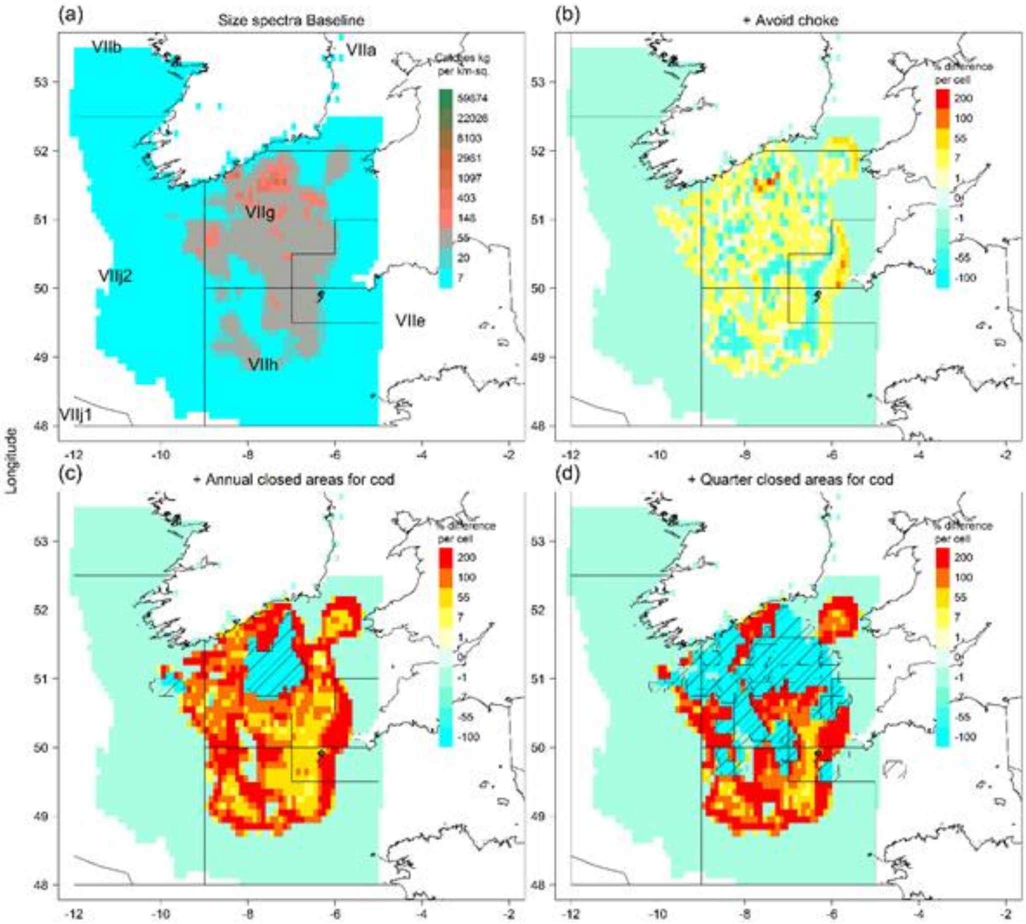


Figure 4.17. Cod catches in the baseline (a) and relative change showing the spatial displacement of catches for selected scenarios induced by a change in fishing vessels decision making (in b), or induced by the closed areas (c- annual, d-quarterly based) on a grid cells of 3 x 3 km including the Irish fleet in the Celtic Sea. The baseline is in absolute values, while the other scenarios are per cent relative to the baseline.

4.8 General conclusions

With the present study, the EWG 21-18 shows that there is a scope to reduce catches of cod and whiting in the Celtic Sea through the implementation of closed areas and periods as a combination of ICES-rectangles and months. A consistent trade-off between the level of targeted catch reductions and the fraction of the economic return that could impact the short-term revenue was identified. The general trend shows that at low levels of catch reduction objectives, the impacted fraction of the financial return would show an almost linear effect, with a slope on revenue lower than the slope in catch reduction. For each stock, this linear trend would reach a tipping point with a large drop in expected revenues. For whiting, this threshold is only reached for a catch reduction target of 70% (revenue losses ~25%), for cod and haddock, the linear relationship found between catch reduction and revenue losses would be much steeper, indicating that closures effects at these levels would increase the risk for stronger economic consequences for those species.

The EWG 21-18 identified convergent information that would support catch reductions of cod to be mainly achieved by closing ICES statistical rectangles off the Central Irish South Coast (31E1, 31E2, 30E0, 30E1, 32E1), with a northeast south-westwards trend throughout the year. However, the same ICES statistical rectangles are identified to reduce whiting catches with an opposite temporal direction. In addition, whiting catches may also be reduced by closing the inshore ICES rectangles south of the Trevose Head in the Western English Channel during winter and spring. The identified ICES statistical rectangles are supported by the underlying biological mechanisms driving the hotspots persistence metrics as supported by the correlation analysis.

The EWG 21-18 observes that all the identified spatio-temporal closures would imply a substantial fleet-specific impact regarding the fraction of the historical revenue affected by the closure. These are directly related to changing the catch opportunities of the fleets. The identified closures for cod and whiting will mainly reduce the revenues of the Irish seine, beam trawl, and otter trawl (OTB_DEF_100-119) métiers and have little impact on the revenues of Belgian beam trawlers and French otter trawlers targeting demersal species (cod) and Spanish otter trawlers and French twin otter trawlers (whiting).

The EWG 21-18 illustrated that potentials for effort displacement would greatly reduce the effectiveness of the closures in reducing catches of cod and whiting. Especially for cod, where closures were focused on the CSPZ, fleets would have the ability to allocate fishing effort to the open areas outside the CSPZ, causing that a targeted catch reduction of, for example, 60% would only result in an effective reduction of 20% of the cod catches. On the other side, the return on the economy from this displacement is, however, likely to be overestimated as long as the hyperstability of catch rates would not apply. Therefore, any closure proposal should probably be accompanied by overall effort reduction plans to reduce unwanted (by)catches and limit increased operating costs and lowered economic return.

Finally, it is unclear how the discrepancy between the discard data in this analysis and the discard statistics provided in the ICES advice sheets would affect the outcome of this analysis. Therefore, it is recommended that a sensitivity analysis should accompany this analysis in the future.

4.9 References

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5 ToR 3. Conduct a bio-economic impact assessment of adopted technical measures, specifically raised-fishing line, and alternative technical measures

This term of reference was to conduct a bio-economic impact assessment of adopted technical measures, specifically the "raised-fishing line" fishing gear specification and alternative technical measures. The bio-economic model should integrate all exploited species and all fleets operating in the Celtic Sea and consider the uncertainty. The EWG should evaluate technical measures with a simulation study to ensure that they meet the sustainability of the resources (cod, whiting, and all possible target species) and economic objectives. The analysis for this term of reference was divided into two main approaches; a static socio-economic assessment and the dynamic bio-economic assessment.

5.1 Static economic impact assessment

The EWG conducted a static economic impact assessment for Ireland, France, Belgium and Spain, following previous used methodologies:

1. Economic loss if choke in 2019 based on STECF PLEN-20-01

2. Catch reduction analysis based on the implementation of the 'raised headline rope'

Hence, the EWG 21-18 agreed to contrast against a realistic baseline to capture the economic impact's reasonable level of magnitude. The catch reduction was analysed against the absence of a "raised fishing line" gear system and also against the situation where no mitigation action is taken, leading to an increased risk for a choke with subsequent economic losses.

5.1.1 Economic loss due to potential choke in 2019

The EWG 21-18 conducted a static analysis of the economic loss associated with a choke of cod using the methodology outlined in STECF PLEN 20-01, which at that time was conducted for French fleets only. During the EWG 21-18, the analysis was extended to incorporate four Member States (Ireland, France, Spain, and Belgium), using bottom trawls (OTB, OTT, PTB), which could potentially be impacted by the implementation of the 'raised fishing line'. This simple analysis provides some information on the possible losses of revenues when the fleet is possibly choked by a limiting (by)catch allowance, especially here on cod. The fraction of revenue realised after the possible choke is compared to the overall revenue to deduce a possible % loss.

However, the EWG observes that such analysis does not incorporate possible fleet adaptation effects that would result from the fishers attempting to limit the losses following the implementation of those measures. The analysis thus provides a limited assessment of changes in the value of 2019 landings when implementing the raised fishing line. Behaviour change would hence influence the cost structure of the vessels and, therefore, the impacts on profits and gross profit margins. As salaries often depend on the overall value of landings, it also influences the average wages of the crew members. In the absence of a readily available bio-economic model, this analysis provides some qualitative information on the possible effects of changing gear to improve selectivity in terms of static short term losses.

An R markdown file with the analysis is also available in Annex 5 (Annex 5 – Bio-economic static analysis 1). EWG 21-18 conducted this analysis using landings and effort supplied to EWG 21-18 for four member states (the "NWW MS group dataset"). The study summarises the impact of the national quota when choked by the bycatch on cod in 2019, assuming the limitations of the 2020 cod quota (805 tonnes) in 2019. EWG 21-18 used this hypothetical scenario to estimate the potential income lost due to the choke of the cod quota. Again, this estimation assumes the fleet would not compensate for losses by fishing elsewhere, which is likely a pessimistic assumption. The quota breakdown by Member states was calculated based on the national quota for cod in 2020. As the analysis only uses a subset of gears (OTB, OTM, PTB), the national quota for 2020 was reduced according to the proportion of landings of the total fleet landed by these specific gears.

The analysis results highlight the potential choke over 20 species concerning the 2020 cod quota. Each Member State reached its quota of cod landings at different points in the year, based on cumulative trips. Figure 5.1 highlights the potential choke points of France (top left), Ireland (top right), Belgium (bottom left) and Spain (bottom right) fleets fishing with bottom trawls (OTB, OTT, PTM). The adapted 2020 quota for the French gear group of all trawls is 280 tonnes (95% of the total quota for France of 294t). The overall impact on the gear group is a reduction in landing volume of 20% with a 24% reduction in landing value (Table 5.1). The Irish trawlers are choked where the adapted national quota of 2020 is 292 tonnes (63% of the total quota for Ireland in 2020 of 461t). Landing volumes fall by 23%, with a consequent reduction in the value of 21% (Table 5.2). For the Belgian trawlers, the adapted quota in 2020 is 4 tonnes (~22% of the total quota for 2020 of 18t). A major impact is estimated for this Belgian fleet, with landing volumes declining 53% with landing values falling by 56% (Table 5.3). Finally, the effect on the Spanish fleet is 100% fishing activity given their lack of quota for cod (Table 5.4).

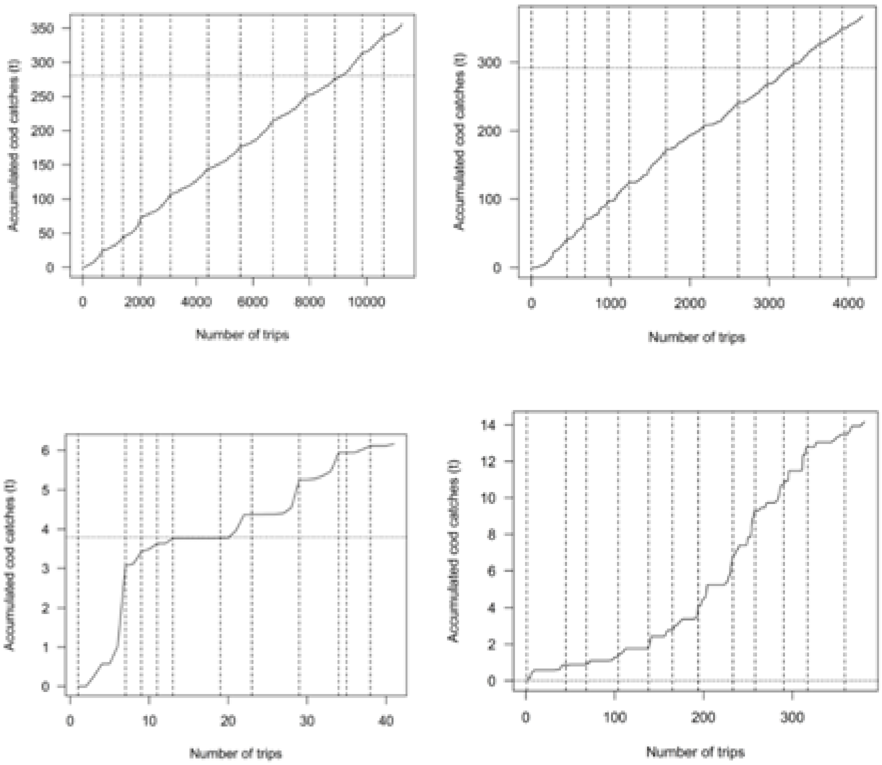

Figure 5.1. Choke points for the trawl gears (OTB, OTM, PTB) by Member State. France (top left), Ireland (top right), Belgium (bottom left) and Spain (bottom right). Cumulated cod landings in 2019 over time. Dashed vertical lines delimit the month periods. The horizontal line is the 2020 cod quota adjusted for Member States and gear grouping.

Table 5.1. Estimated impact of cod choke on activity of French trawl gears (OTB, OTM, PTB) on 20 species in terms of landings (tonnes) before and after the choke in cod, assuming applying the 2020 French cod quotas (280 tonnes) was available in 2019 French dataset.

Species	Landings before choke (tonnes)	Landings after choke (tonnes)	% difference	'000 euros before choke	'000 euros after choke	% difference
MNZ	8165	2199	-21	35788	12550	-26
HAD	3615	835	-19	7713	1997	-21
WHG	2641	471	-15	4583	1179	-20
HKE	1723	407	-19	4243	1364	-24
LEZ	1689	431	-20	5063	1760	-26
GUR	1472	302	-17	1039	216	-17
CTC	1313	485	-27	4352	1308	-23
BIB	1173	230	-16	799	225	-22
RJN	1047	275	-21	1957	513	-21
SYC	1024	194	-16	447	105	-19
MEG	997	216	-18	2917	875	-23
SDV	885	271	-23	1222	345	-22
JOD	846	175	-17	8994	1989	-18
COE	708	272	-28	681	221	-24
LEM	498	92	-16	2355	514	-18
RJM	463	104	-18	1038	252	-20
RJH	345	154	-31	787	345	-30
WIT	321	117	-27	706	277	-28
SQZ	309	233	-43	2739	1323	-33
COD	280	76	-21	1166	322	-22
Others	3547	911	-20	14315	4090	-22
Total	33061	8450	-20	102904	31770	-24

Table 5.2. Estimated impact of cod choke on activity of Irish trawl gears (OTB, OTM, PTB) on 20 species in terms of landings (tonnes) before and after the choke in cod, assuming applying the 2020 Irish cod quotas (292 tonnes) was available in 2019 Irish dataset.

Species	Landings before choke (tonnes)	Landings after choke (tonnes)	% difference	'000 euros before choke	'000 euros after choke	% difference
NEP	4624	596	-11	27560	3453	-11

ANF	1367	640	-22	4949	2511	-24
WHG	1169	396	-17	1805	658	-21
HAD	1100	504	-32	1990	1022	-35
LEZ	1055	298	-31	3099	962	-32
HKE	519	135	-20	1444	467	-22
RAJ	355	167	-31	557	284	-33
COD	292	76	-21	922	256	-22
WIT	222	79	-25	387	142	-25
LEM	149	33	-16	438	103	-16
JOD	138	21	-12	772	135	-14
SQE	111	96	-29	301	297	-30
PLE	107	42	-46	218	93	-50
LIN	81	22	-22	128	39	-24
SOL	80	39	-12	779	436	-12
POL	75	12	-32	184	31	-35
CTC	74	286	-80	368	1327	-78
TUR	46	13	-21	456	142	-22
SYC	41	30	-15	23	19	-13
OTH	29	NA	-42	70	NA	-44
Others	231	144	-38	645	479	-43
Total	11865	3629	-23	47095	12856	-21

Table 5.3. Estimated impact of cod choke on activity of Belgium trawl gears (OTB, OTM, PTB) on 20 species in terms of landings (tonnes) before and after the choke in cod, assuming applying the 2020 Belgium cod quotas (4 tonnes) was available in 2019 Belgium dataset.

Species	Landings before choke (tonnes)	Landings after choke (tonnes)	% difference	'000 euros before choke	'000 euros after choke	% difference
SOL	28	36	-56	350	446	-56
RJH	27	31	-53	55	63	-53
RJC	24	19	-44	41	33	-44
PLE	17	20	-55	41	51	-55
LEZ	10	18	-63	20	34	-63
RJI	10	4	-29	16	7	-29
HAD	8	2	-17	14	3	-17

RJN	5	0	-3	7	0	-3
ANF	5	11	-67	51	104	-67
SYC	4	8	-67	2	4	-67
COD	4	3	-40	12	8	-40
WHG	3	14	-84	3	15	-84
WIT	2	4	-61	4	6	-61
POL	2	1	-24	9	3	-24
DAB	2	3	-65	1	3	-65
JOD	2	1	-47	11	10	-47
NEP	1	1	-34	7	4	-34
GUU	1	NA	NA	1	NA	NA
LEM	1	1	-62	3	5	-62
SYT	1	1	-49	0	0	-49
Others	6	8	-57	22	38	-63
Total	163	186	-53	670	837	-56

Table 5.4. Estimated impact of cod choke on activity of Spanish trawl gears (OTB, OTM, PTB) on 20 species in terms of landings (tonnes) before and after the choke in cod, assuming applying the 2020 Spanish cod quotas (0 tonnes) was available in 2019 Spanish dataset.

Species	Landings before choke (tonnes)	Landings after choke (tonnes)	% difference	'000 euros before choke	'000 euros after choke	% difference
LEZ	5	2274	-100	19	8586	-100
ANF	3	2813	-100	NA	NA	NA
RJO	2	115	-98	NA	NA	NA
RJN	1	130	-99	2	327	-99
HKE	0	1890	-100	1	7471	-100
HAD	0	81	-100	0	124	-100
EOI	0	90	-100	0	237	-100
LEM	0	67	-100	0	179	-100
SQI	NA	920	NA	NA	2395	NA
WIT	NA	281	NA	NA	768	NA
NEP	NA	135	NA	NA	1330	NA
GFB	NA	93	NA	NA	324	NA

SQE	NA	80	NA	NA	167	NA
JOD	NA	50	NA	NA	394	NA
MAC	NA	41	NA	NA	63	NA
COE	NA	40	NA	NA	66	NA
RED	NA	34	NA	NA	59	NA
OCM	NA	33	NA	NA	NA	NA
LIN	NA	27	NA	NA	50	NA
BRF	NA	18	NA	NA	51	NA
Others	0	107	-100	0	350	-100
Total	11	9319	-100	22	22941	-100

5.1.2 Catch reduction analysis

The EWG 21-18 conducted a catch reduction analysis using the NWW MS dataset provided to this EWG. This analysis detailed the impact on all vessels using OTB, OTT and PTM gears, for which it is considered possible to implement the 'raised line' fishing gear selectivity measure. These impacts were defined based on a 2019 study by BIM, from which impacts of proportions were taken (McHugh et al., 2019). The R code and the details of this analysis can be found in RMarkdown file in Annex 6 (EWG-21-18 – Annex 6 – Bio-economic static analysis 2. Catch reduction). The detailed breakdown by Member State can be found in Tables 5.7–5.10. A summarised version of the impacts by MS is in Table 5.5 and Figure 5.2. The analysis shows that potential reductions in the catch when implanting the headline rope are as follows:

- French fleet is impacted with a 40-52% reduction in volume and a 41-54% reduction in value.

- Irish fleet is impacted with a 36-44% reduction in volume and a 40-47% reduction in value.

- Belgian fleet is impacted with a 66% reduction in volume and a 64% reduction in value.

- Spanish fleet is impacted with a 57-61% reduction in volume and a 61-65% reduction in value.

Table 5.5. Summary of impacts from static analyses on choke species and implementation of 'raised line' fishing gear adaptation.

	Volume		Value	
	Choke	Raised Line (average)	Choke	Raised Line (average)
FRA	-20%	-46%	-24%	-47%
IRL	-23%	-40%	-21%	-43%
BEL	-53%	-66%	-56%	-64%

ESP	-100%	-59%	-100%	-63%
ALL	-32%	-41%	-31%	-46%

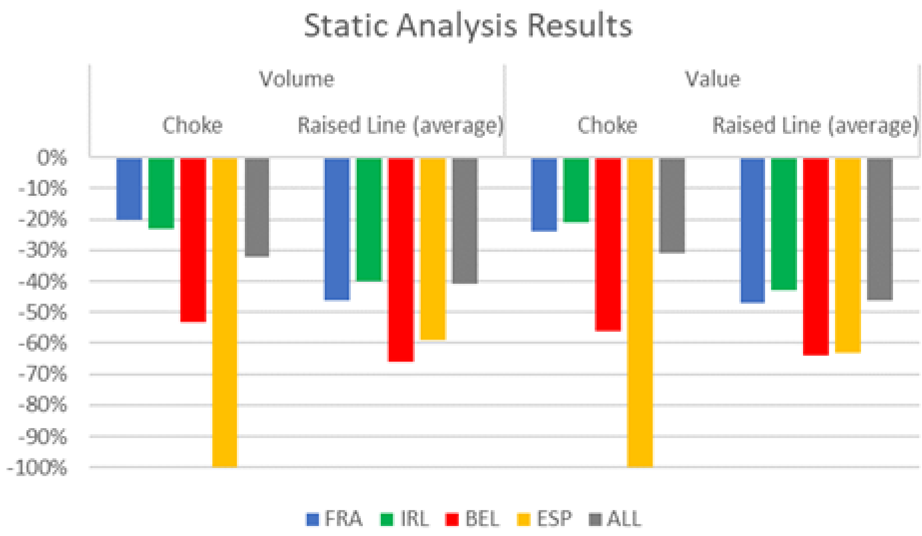

Figure 5.2. Summary of impacts from static analyses on choke species and implementation of 'raised line' fishing gear adaptation.

Table 5.6. Scenarios on impacted vessels (2017-2019) including possible catch reduction from the 'raised line'- updated table for all fleets.

Scenario	No. Vessels	No. Trips	Total landings (tonnes)	COD landings (tonnes)	HAD landings (tonnes)	WHG landings (tonnes)	Value (€)	Total landings reduced (tonnes)	Total landings reduced (tonnes) % difference	Value (€) reduced	Value (€) reduced % difference	COD landings (tonnes) reduced	COD landings (tonnes) %diff	Cost per cod ton saved ('000 €)
Perfect knowledge (ie trips inside, >20%HAD)	208	1800	9287	550	2972	751	27080	5605	-40	16044	-41	391	-29	69
Concerned vessels only (ie at least 1 trip inside >20%HAD)	208	12584	55686	2440	6156	8488	183441	30201	-46	96682	-47	1732	-29	123
Concerned vessels only, + all crossing trips	208	12585	71798	2637	9959	9251	235462	38654	-46	121917	-48	1872	-29	148
Whole fleet, within CSPZ	301	14595	71678	2647	6475	8737	226650	36661	-49	113880	-50	1879	-29	147
Whole fleet, + all crossing trips	308	14634	103433	2876	10429	9513	316715	51753	-50	153544	-52	2042	-29	196

Table 5.7. Scenarios on impacted vessels (2017-2019) including possible catch reduction from the 'raised line'- French fleet.

Scenario	No. Vessels	No.Trips	Total landings (tonnes)	COD landings (tonnes)	HAD landings (tonnes)	WHG landings (tonnes)	Value (€)	Total landings reduced (tonnes)	Total landings reduced (tonnes) % difference	Value (€) reduced	Value (€) reduced % difference	COD landings (tonnes) reduced	COD landings (tonnes) %diff	Cost per cod ton saved ('000 €)
Perfect knowledge (ie trips inside, >20%HAD)	80	1038	7381	462	2370	433	22145	4392	-40	13080	-41	328	-29	68
Concerned vessels only (ie at least 1 trip inside >20%HAD)	80	3702	22593	1386	3831	984	71410	11533	-49	36684	-49	984	-29	86
Concerned vessels only, + all crossing trips	80	3703	35952	1528	6197	1693	115562	18193	-49	57157	-51	1085	-29	132
Whole fleet, within CSPZ	107	4208	26342	1489	3992	1000	85995	12924	-51	41839	-51	1057	-29	102
Whole fleet, + all crossing trips	107	4209	45886	1657	6476	1715	155560	21854	-52	71168	-54	1177	-29	176

Table 5.8. Scenarios on impacted vessels (2017-2019) including possible catch reduction from the 'raised line'- Irish fleet.

Scenario	No. Vessels	No. Trips	Total landings (tonnes)	COD landings (tonnes)	HAD landings (tonnes)	WHG landings (tonnes)	Value (€)	Total landings reduced (tonnes)	Total landings reduced (tonnes) % difference	Value (€) reduced	Value (€) reduced % difference	COD landings (tonnes) reduced	COD landings (tonnes) %diff	Cost per cod ton saved ('000 €)
Perfect knowledge (ie trips inside, >20%HAD)	128	762	1906	89	602	318	4934	1212	-36	2964	-40	63	-29	77
Concerned vessels only (ie at least 1 trip inside >20%HAD)	128	8882	33093	1054	2325	7504	112030	18669	-44	59998	-46	748	-29	170
Concerned vessels only, + all crossing trips	128	8882	35846	1109	3762	7559	119900	20461	-43	64760	-46	788	-29	171
Whole fleet, within CSPZ	159	9668	35615	1123	2410	7703	124688	19984	-44	66471	-47	798	-29	179
Whole fleet, + all crossing trips	159	9668	38644	1183	3864	7761	133828	21921	-43	71888	-46	840	-29	181

Table 5.9. Scenarios on impacted vessels (2017-2019) including possible catch reduction from the 'raised line'- Belgian fleet.

Scenario	No. Vessels	No. Trips	Total landings (tonnes)	COD landings (tonnes)	HAD landings (tonnes)	WHG landings (tonnes)	Value (€)	Total landings reduced (tonnes)	Total landings reduced (tonnes) % difference	Value (€) reduced	Value (€) reduced % difference	COD landings (tonnes) reduced	COD landings (tonnes) %diff	Cost per cod ton saved ('000 €)
Perfect knowledge (ie trips inside, >20%HAD)	0	0	0	0	0	0	0	0	NA	0	NA	0	NA	NA
Concerned vessels only (ie at least 1 trip inside >20%HAD)	0	0	0	0	0	0	0	0	NA	0	NA	0	NA	NA
Concerned vessels only, + all crossing trips	0	0	0	0	0	0	0	0	NA	0	NA	0	NA	NA
Whole fleet, within CSPZ	7	89	760	22	32	34	3212	257	-66	1153	-64	16	-29	321
Whole fleet, + all crossing trips	7	89	780	22	32	37	3317	265	-66	1192	-64	16	-29	330

Table 5.10. Scenarios on impacted vessels (2017-2019) including possible catch reduction from the 'raised line'- Spanish fleet.

Scenario	No. Vessels	No. Trips	Total landings (tonnes)	COD landings (tonnes)	HAD landings (tonnes)	WHG landings (tonnes)	Value (€)	Total landings reduced (tonnes)	Total landings reduced (tonnes) % difference	Value (€) reduced	Value (€) reduced % difference	COD landings (tonnes) reduced	COD landings (tonnes) %diff	Cost per cod ton saved ('000 €)
Perfect knowledge (ie trips inside, >20%HAD)	0	0	0	0	0	0	0	0	NA	0	NA	0	NA	NA
Concerned vessels only (ie at least 1 trip inside >20%HAD)	0	0	0	0	0	0	0	0	NA	0	NA	0	NA	NA
Concerned vessels only, + all crossing trips	0	0	0	0	0	0	0	0	NA	0	NA	0	NA	NA
Whole fleet, within CSPZ	28	630	8962	12	41	0	12756	3497	-61	4418	-65	9	-29	2363
Whole fleet, + all crossing trips	35	668	18122	14	58	0	24011	7713	-57	9295	-61	10	-29	3617

5.1.3 Conclusions

Both static economic assessments indicate that implementing the 'raised fishing line' selectivity device on trawls in the Celtic Sea Protection Zone has a potentially higher short-term negative economic impact than the fishery being choked and activity restricted for the French, Irish and Belgian trawl fleets. However, the impact of the 'raised line' is positive for the Spanish fleet, preventing this fleet from being choked immediately due to lack of cod quota and lowering the impact from 100% of activity, in terms of landing volume and value, to 32%.

However, this coarse comparison shows that in terms of short-term losses in the absence of any fleet adaptation, the implementation of the 'raised fishing line' would have the same magnitude of impact as the early closure of the fishery.

The EWG observes that these outcomes are deduced from a static analysis that only addresses short term effects on a minimal number of thresholds. Although these findings are relevant to the Celtic Sea Protection Zone, they are not exhaustive or without limitations and do not consider feedback effects from positive impacts on recruitment of the cod stock in the future. Therefore, further (dynamic modelling) explorations need to be conducted to determine the mixed fisheries impact of implementing varying thresholds and/or trigger species, following the threshold analysis provided in ToR1.

5.2 Dynamic bio-economic assessment

FLBEIA was identified as an appropriate model to conduct a bio-economic impact assessment of technical measures within the Celtic Sea. FLBEIA is a simulation toolbox based on the fisheries library in R (FLR) (García et al., 2017) that can be used to conduct bio-economic impact assessments of fisheries management strategies. The model is set within a management strategy evaluation framework and has no limitation in the number of the stocks, fleets, seasons or iterations that can be incorporated. FLBEIA provides a tool to integrate age-based catchability specifications to fleets and métiers. The model can forecast mixed fisheries projections for each fleet and therefore could test the impacts of specific gears such as the raised-fishing line and alternative technical measures.

This term of reference was to evaluate the impact of technical measures with a simulation study to ensure that they meet the sustainability of the resources (cod, whiting, and all possible target species) and in terms of economic objectives. To the EWG 21-18's knowledge, there are currently no FLBEIA models readily available that could be used to conduct this analysis. Therefore, a model would have to be developed from the foundation up. Building and parameterising an FLBEIA model for this purpose would take several months. Consequently, it could not be done in the timeframe of this working group. Valuable progress and insights could be made in three main areas: data and model evaluation and scenario development required to ensure a future EWG could conduct a meaningful analysis.

5.2.1 Data Evaluation

The input data for FLBEIA bio-economic assessment is a FLFleet object. This object is built using four main types of data: catch (tonnes), value (euros), effort (kWdays), age structure by métier (numbers in thousands and mean weight-at-age in g), and single-species stock assessment (inputs including biological parameters, outputs in terms of population numbers and forecast settings including future recruitment assumptions). The EU requested an age-disaggregated FLFleet object used in producing mixed fisheries advice from ICES earlier this year. The Celtic Sea mixed fisheries advice is currently built using FCube, which does not require incorporating a split per age. Therefore no fleet object with age-disaggregation is presently available. However, EWG 21-18 observes that ICES WGMIXFISH could be in a position to provide such FLFleet objects in the future, and the Celtic Sea subgroup worked to create an age disaggregated fleet during last IBPMIXFISH and WGMIXFISH-Advice, a fleet object although not used in the production of advice may be of use to future STECF EWGs.

The EWG 21-18 observes that this new product could potentially be requested through ICES in the future. This object would be key to producing a practical model as it has been quality controlled and checked for internal inconsistencies. The outcomes of forecasts in FLBEIA are susceptible to deviations in internal consistency, which can result in invalid conclusions if left unchecked. These checks include checks of numbers at age and consistency with other available and established data sources such as ICES single species advice (total tonnage) and effort (ICES WGMIXFISH accessions). During this EWG 21-18 it has been suggested that all available stocks be incorporated. Therefore when making this request to ICES, the EWG would suggest broadening that request to include an age disaggregated fleet object (which does not have to have been used in the production of ICES advice), and stock objects for all available stocks within the Celtic Sea (Cat 1- 6).

In the absence of this information, the EWG 21-18 explored the availability of national 'InterCatch' age data to see if this could be merged with the data available through this EWG's data call. This process required data processing, cleaning and assumption application, as the two data types are at different spatial and temporal resolutions and contain other units of fisher behaviour. France, Spain and Ireland made this data available during the EWG 21-18. However, experts found that the two datasets could not be merged for two main reasons: mismatch in total landings and fisher behaviour units (métiers). The difference in the total landings declared in data files containing age and landings available in the data for this EWG made it questionable to merge the two data sets during the time frame of the EWG. An example of these differences can be seen in cod, where a 500 tons difference in the declared landings of France and Ireland, between the two data sources (Figure 5.3). These differences could not be resolved without exploring the selectivity-at-age for each métier, which would facilitate the definition of assumptions for aggregation, for example, by plotting trends in catches-at-age by metier over time to see if there are métier based differences in selectivity at age.

These assumptions could significantly affect the outcomes of the models in terms of fishing mortality, spawning stock biomass, and catch. This could be resolved by requesting data from the Member States more explicitly. If requesting effort and catch data at the level of the statistical rectangle, it must also be requested that data be raised to the level of nationally declared landings recorded and reported at the level of ICES divisions. Therefore, totals of landings will be consistent with declarations of the whole trip and match the totals submitted to other sources (i.e. Eurostat, ICES Intercatch, STECF FDI). Other mismatches in landings were caused by the lack of full stock coverage for the key stocks being discussed in this EWG. ICES division 27.7.d was not requested in this data call. Therefore the stock and management area for had.27.7b-k was not available in the data provided and could not be compared to the TAC management unit (Figure 5.4).

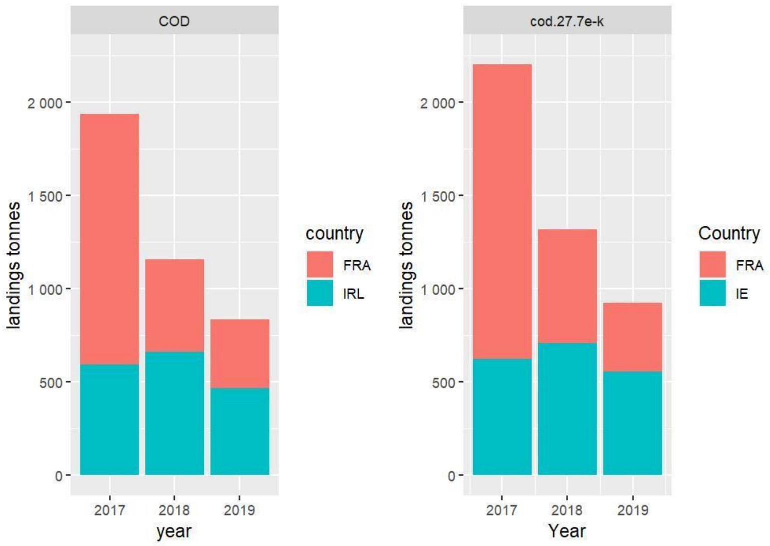

Figure 5.3. Differences in total landings declared in the data call by France and Ireland for this EWG 21-18 (left) and those submitted to ICES in the form of age disaggregated data (right).

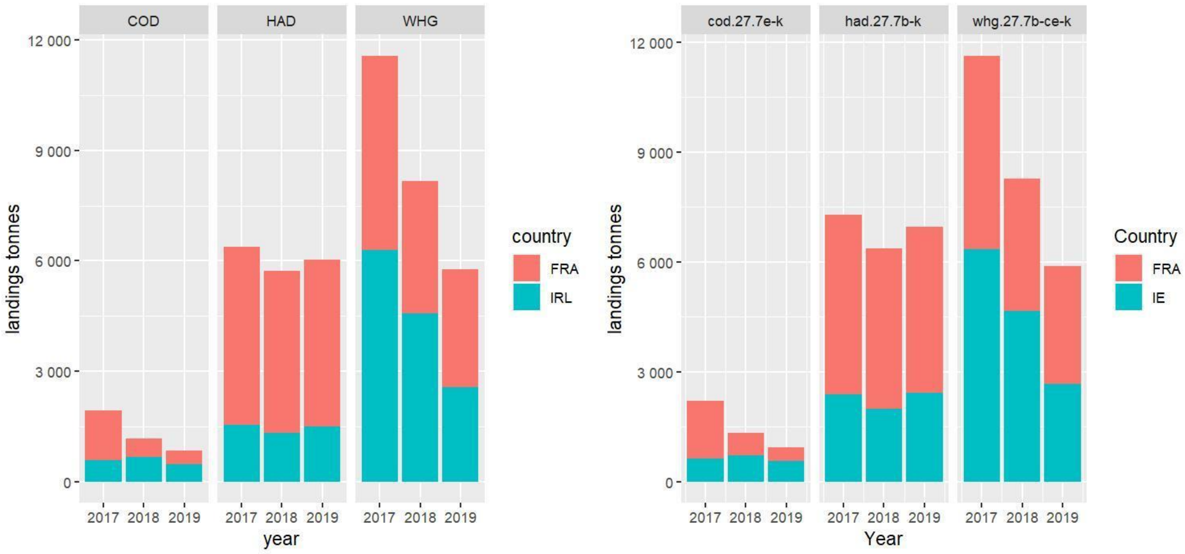

Figure 5.4. Differences in total landings declared in the data call for this EWG 21-18 (left) and those submitted to ICES in the form of age disaggregated data (right).

An additional obstacle to merging the two data sets was the diversity of units of fisher behaviour (i.e. metiers) available in both data sets (Figure 5.5). The NWW MS dataset presented some typos and uncompleted names for métiers that avoid following the established list of métiers used by FDI (https://datacollection.jrc.ec.europa.eu/dc/fdi) or ICES (https://vocab.ices.dk/). The métier label forms an important unit by which to interrogate catchability. Indeed, member state variation in métiers and spatial resolution can strongly influence trends in catch composition over time (Davie and Lordan, 2011; Moore et al., 2019; Robert et al., 2019).

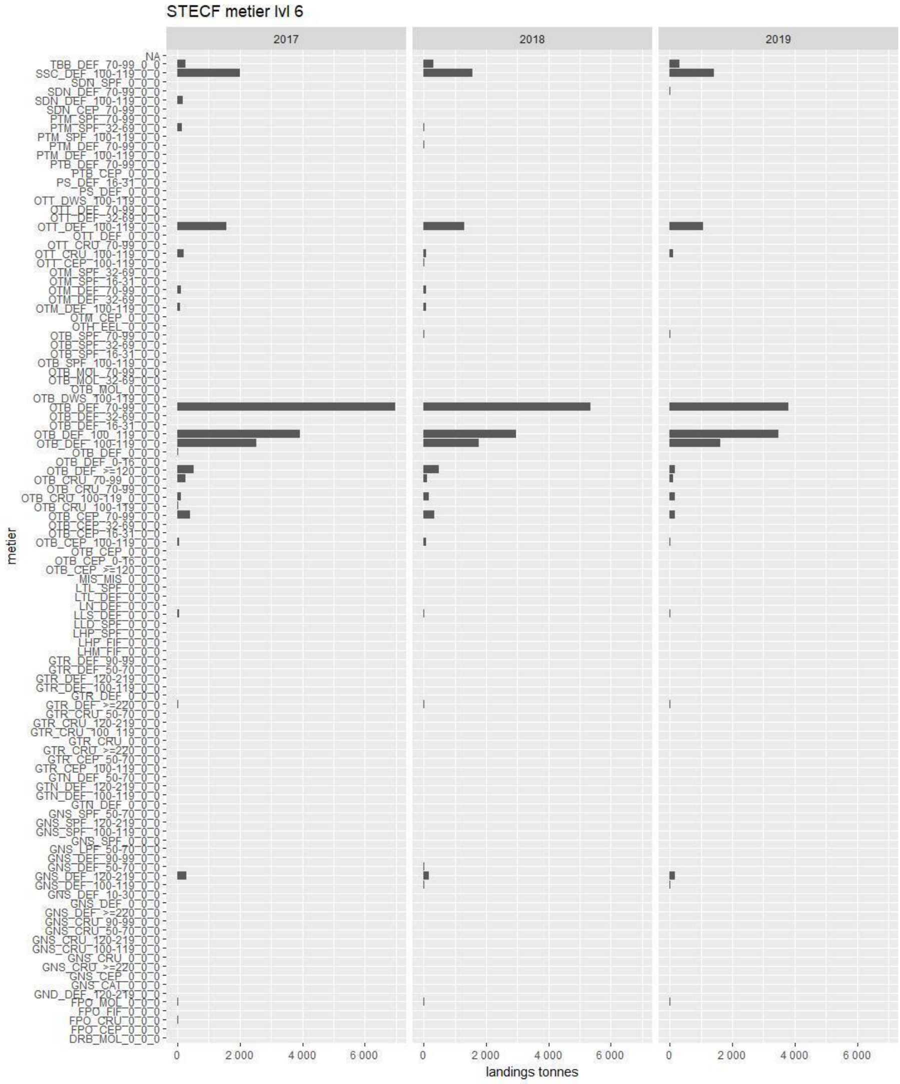

Figure 5.5. Different métiers submitted to EWG 21-18.

5.2.2 Initial insights into fisher behaviour

Despite the limitations of the available data, some valuable insights were evident. Inspection of the landings profile highlighted the low landings of cod in the Celtic Sea, where cod (dark blue) forms a very low proportion of each métier (Figure 5.6). From this plot, it can be seen that the top 5 métiers executed in the area are by French otter trawlers (FRA_OTB_DEF), French gillnetters (FRA_GNS_DEF), Spanish long liners (ESP_LLS_DEF) and Irish otter trawlers (IRL_OTB_DEF) (Figure 5.6). There is also evidence of member state-specific differences in the results of specific fisher behaviour. Despite using the same gear (OTB) and targeting the same assemblage (DEF) there are striking differences in the proportions of species being targeted and landed by different member states in particular France and Ireland, where there Member States specific differences in proportions of whiting (WHG), anglerfish (MON) and hake (HKE) (Figure 5.6).

These plots also highlight that OTB_DEF is the main métier landing cod and whiting in the Celtic Sea (Figure 5.6), accounting for more the 50% of the landings for these stocks. Therefore, any measure to reduce landings of these stocks would impact these métiers the most.

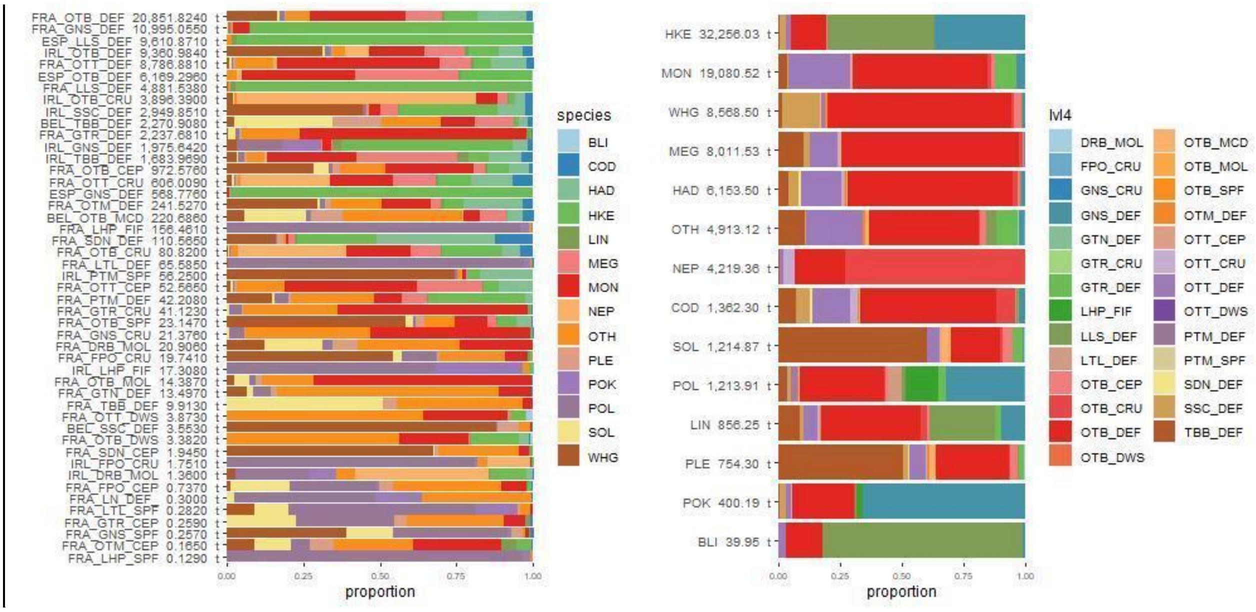

Figure 5.6. Description of technical interactions of fleets catching cod and other associated demersal species in the Celtic Sea (27.7bc, e-k), created from the data submitted for this EWG 21-18. Each bar in the left panel shows the 2017-2019 average catch composition of the main demersal métiers operating in this area. The right panel shows the main métiers landing individual species. The label incorporates the country code, métier, and mean annual (2017–2019) landings (tonnes).

5.2.3 Model

Model suitability

During a recent inter-benchmark at ICES, it was found that FLBEIA was not a suitable model to forecast cod.27.7e-k (ICES, 2021). Here follows the important extract from this report:

It was found that there can be large differences in realised fishing mortalities when applying a Cobb-Douglas production function (used by default in FLBEIA) instead of a Baranov catch equation. This is due to the fact that Cobb-Douglas production function discretises catch at a single point in time halfway through the year. While in general these differences are small at moderate fishing mortality rates and moderate to high natural mortality rates, it led to inconsistencies for Celtic Sea cod that were considered problematic. These inconsistencies are due to the current high fishing mortality on the stock and historic low stock size. As a result, when the FLBEIA model was conditioned on average catchabilities from the past three years (2017 – 2019) fishing effort only slightly higher than current levels resulted in a very large fishing mortality (Figure 5.7). This was particularly problematic for the ages 3-7 (which encompass the Fbar range for the stock of 2-5) where the catch projections deviate, and calculated fishing mortalities are quite different between the Baranov approach and the Cobb-Douglas approach.

The higher catchabilities and fishing effort (Figure 5.9) in 2017 when the population was in a better condition were leading to higher average values than the values in 2019 (2017-2019 average was higher than 2019). Conditioning the model-based catchabilities and effort levels in 2019 led to an improved model (Figure 5.8) but with still a ceiling of 1.3x current effort levels before the artificial cap on fishing mortality was introduced (and a non-linear effort-F relationship).

Ideally, the Baranov catch equation would be used in FLBEIA to provide consistency with single stock approaches. However, this is difficult to implement due to the need to apply it simultaneously to all fleets and work so far has not yet found a satisfactory solution. This should be a priority and considered necessary for the Celtic Sea case study to progress given the divergence in catch model between the single stock advice and FLBEIA at levels of effort only moderately higher than currently observed.

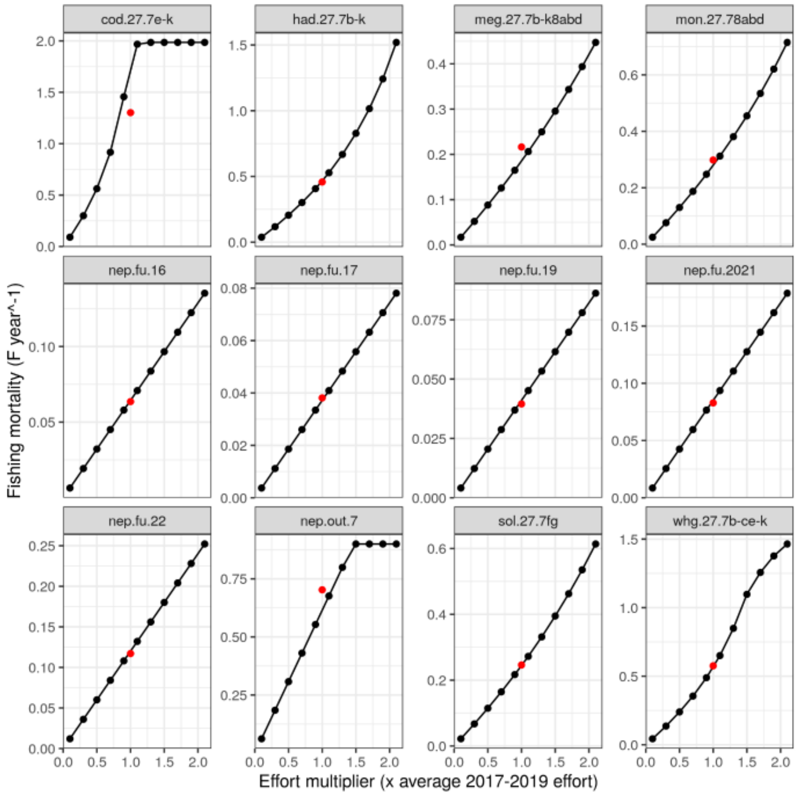

Figure 5.7. The relationship between fishing effort and realised fishing mortality (Fbar) for each stock in the Celtic Sea model (conditioned on average catchabilities 2017-2019).

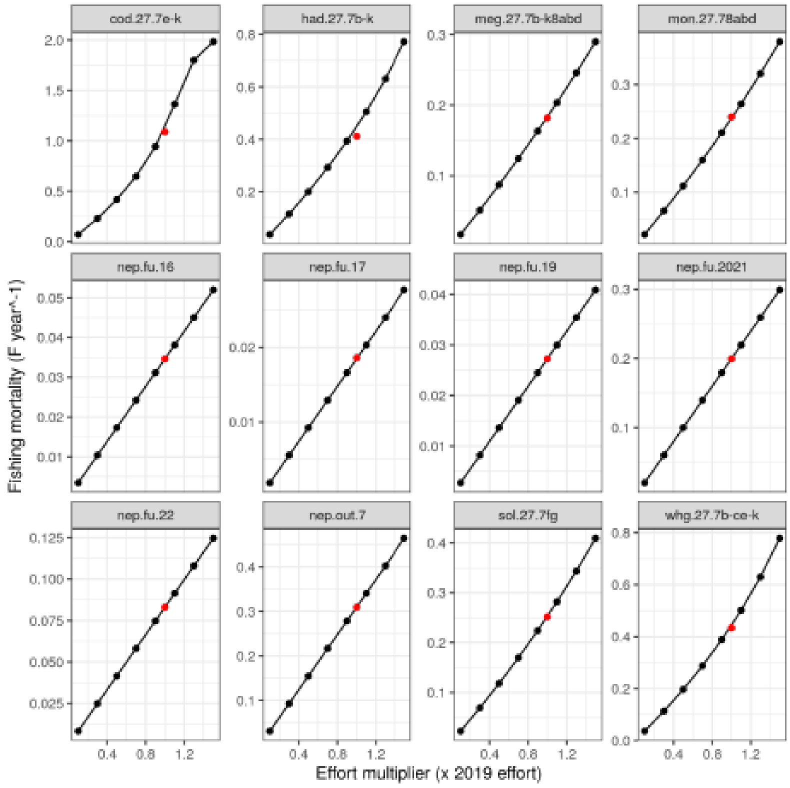

Figure 5.8. The relationship between fishing effort and realised fishing mortality (Fbar) for each stock in the Celtic Sea model (conditioned last year's catchabilities; 2019).

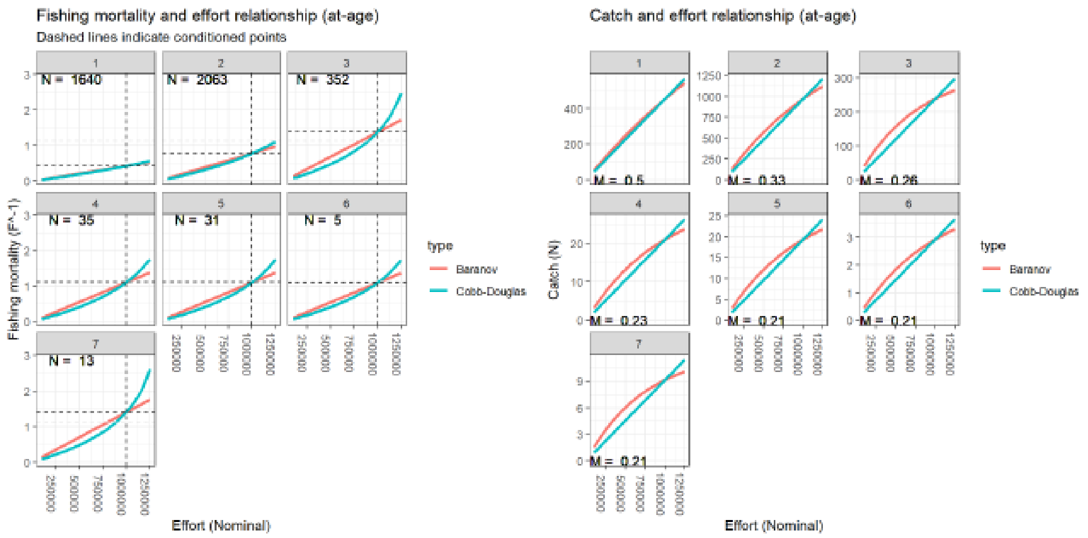

Figure 5.9. The relationship between fishing effort and fishing mortality-at-age (left panels) and catch (numbers in 000, right panels) under a Cobb-Douglas and Baranov equation. The numbers of fish in the population are shown inset in the left panels, the natural mortality in the right panels.

Current FLBEIA models

Once the issues with FLBEIA Cobb–Douglas function have been resolved then the tools developed in a recent Irish project might be a good template for future work. This project between Bord Iascaigh Mhara, Marine Institute and CEFAS, created a bio-economic assessment of the impact of the landing obligation on 52 stocks in the Celtic Sea. During the project a framework was built based on common data structures used within European, Annual Economic report, FDI and InterCatch. These data inputs were merged using Irish data and fed into a purpose built R package which builds an age disaggregated fleet object, models forecasts within FLBEIA and produces a "R shiny" application for exploring the results in terms of biological parameters (F, SSB, and Catch) and economic parameters (employment, profit). This package contains functions that would be useful to future analysis in this area where catchability of a gear type can be easily changed and implemented, for example:

```
change_q(name = "shortname", fleet = "Otter_trawlers_18<24m", metier =
"OTB_DEF_100-119_27.7.e-k", stk = "cod.27.7e-k", ages = "all", rel_change = 0.5)
```

Also the app provides a tool to quickly explore impacts of these selectivity changes per fleet and stock. The implications of changes in effort and TAC set out under each scenario is outlined in the section on 'Potential choke species for each fleet segment in 2021'. These plots will provide useful decision tools for managers and users of the advice. The adaptation of this model to account for other data sources, Member States and spatial resolutions would take several weeks work and much effort, but it could be a useful option.

5.2.4 Scenarios to evaluate

Definition of scenarios and assumptions, to ensure meaningful and interpretable results we need to first outline the scenarios/questions to be modelled in FLBEIA (i.e. status quo effort, number of years to project, capacity limits). One particular scenario would be to assess the implementation of the headline rope technical measure; the EWG explored two fishing gear studies conducted by Ireland's Seafood Development Agency (BIM) to the South of Ireland in 2017 (McHugh et al., 2017) and 2019 (McHugh et al., 2019). During these gear trials, catches from a raised fishing line and a standard fishing line were compared. The first study towed both gears simultaneously at 11 locations in ICES Division 7g, while the second study alternated both gears along with a total of 24 hauls in ICES Divisions 7g and 7a.

The raised fishing line shows a reduction of catches from all species in the latest study and almost all species in the first study, including cod, hake, monkfish and flatfish species (Figure 5.10). However, in the first study, the "raised line" caught more haddock and whiting than the standard line (Figure 5.10). These different results might be explained by variations in the gear configurations of each trial. The 2019 study is considered more realistic and comparable to commercial gear configuration, and thus, outputs from this study should be applied in future analyses on the effect of raised fishing lines.

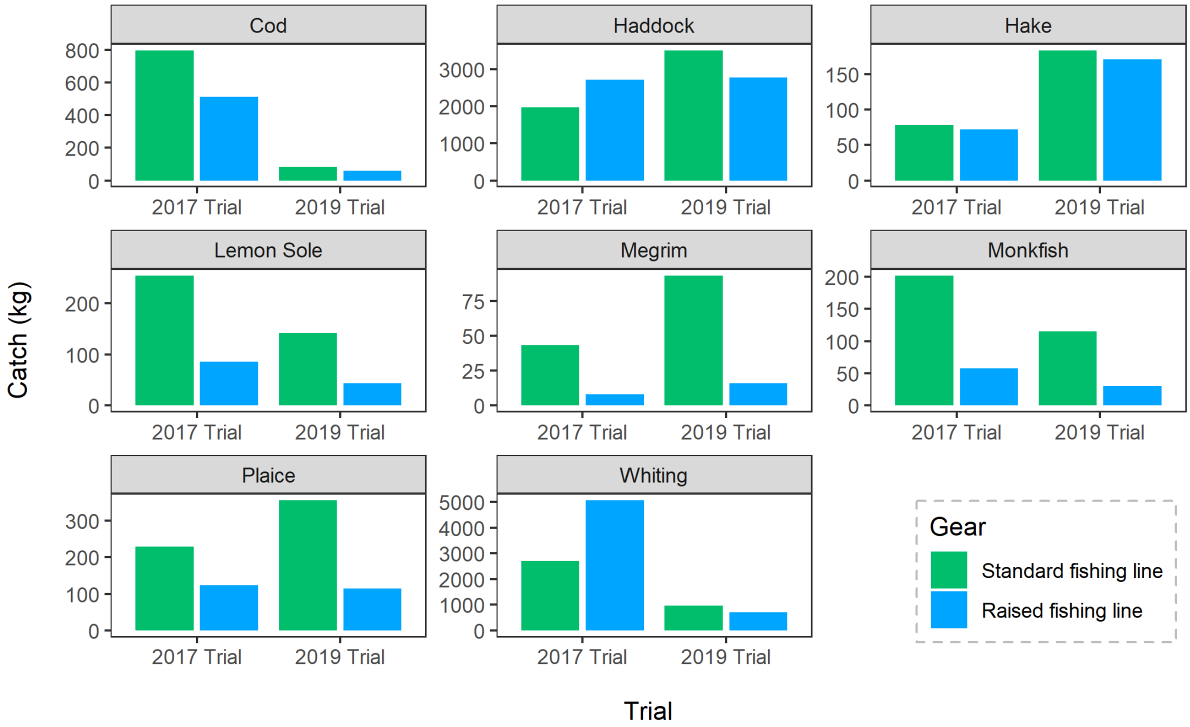

Figure 5.10. Catches by species and gear in BIM gear trials of 2017 and 2019.

5.2.5 Conclusions

In conclusion, this EWG determined that there was no available FLBEIA model to assess the impacts of technical measures in the Celtic Sea. Such a model would need to be built from the ground up and would require quality control data inputs to ensure that any conclusions/recommendations from the model outcomes would be informative and meaningful.

A number of data inputs are required to achieve this:

A FLFleet object: this is an age disaggregated fleet object containing member state specific métier level information on stock, catches, landings and discards, in terms of numbers at age, weights at age, catchability and biomass trends. This would have to be requested through ICES.

FLStock objects: For all species of interest within the area from all assessment categories (1-6). Category 1 – 3 stocks would contain data used in the assessment. Higher category stocks would contain data on total landings, discards and catches only.

Fisheries dependent information: The data call used for this EWG did not fit the required input for developing an age-structure FLBEIA. Besides this, estimates of landings and effort at the level of statistical rectangle should add up to the total. A consistent list of métier definitions should still be used (DCF metier level 6), and finally, full management area should best be requested (i.e include 7.d) to be able to inform the model on the entirety of the stock areas.

EWG observes that conditioning a dynamic bio-economic model usually takes several weeks. Although some frameworks already exist these are not purpose built and would take intersessional time to parametrise and develop.

5.3 References

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Robert, M., Calderwood, J., Radford, Z. et al. 2019. Spatial distribution of discards in mixed fisheries: species trade-offs, potential spatial avoidance and national contrasts. Rev Fish Biol Fisheries 29, 917–934. https://doi.org/10.1007/s11160-019-09581-z.

6 TOR 4. Evaluate, to the extent possible, the potential effectiveness of the measures to be introduced by the UK from the 5 the September 2021 on cod and whiting stocks in the Celtic Sea in comparison to the current measures in EU waters. Comment any issues that the differences in measures create

General Comments

The UK introduced new technical measures in the Celtic Sea from the 5th September 2021. These measures apply only in UK waters and differ quite significantly to the current EU measures in place in the Celtic Sea as detailed in Table 6.1 and Figure 6.1 below. The UK regards these measures as improvements to the EU regulations that will improve the overall selectivity of fisheries in UK waters in the Celtic Sea.

The introduction of these measures means that Union vessels are now subject to different technical measures when fishing in EU and UK waters during the same fishing trip. It is not clear yet how fishers have and will adapt to this, but over time it may result in different gears being used and the exploitation pattern for cod and whiting changing. It is also apparent that the UK may seek to make further changes to the technical measures in the Celtic Sea creating further divergence between EU and UK measures. To this end the UK has indicated that future measures will be targeted at catches of cod as the most vulnerable stock, with less reliance on assumptions around catch composition.

The main changes introduced by the UK are:

1. The establishment of a minimum codend mesh size of 110 mm and square mesh panel with a minimum mesh size of 120 mm mesh as the default gear for with otter trawls and bottom seines in the Celtic Sea Protection Zone (ICES divisions from 7f, 7g, the part of 7h North of latitude 49° 30' North and the part of 7j North of latitude 49° 30' North and East of longitude 11° West). In the rest of the Celtic Sea in UK waters (ICES divisions 7efghjk), the default mesh size is 100 mm with 100 mm square mesh panel.
2. The removal of the requirement to use the raised fishing line gear in gadoid fisheries with catches of greater than 20% of haddock.
3. A different catch threshold for vessels fishing for Nephrops (i.e., 30% in EU waters compared to 5% in UK waters)
4. A derogation to allow vessels operating with otter trawls and bottom seines with catches comprising less than 10% of gadoids ICES division 7f East of longitude 5° West, to use a minimum codend mesh size of 80 mm and a square mesh panel with a minimum mesh size of 120 mm.
5. A derogation to allow vessels operating with otter trawls and bottom seines in the part of ICES division 7f West of longitude 5° West, inside 12 nautical miles of the coast of the United Kingdom, to use a minimum codend mesh size of 100 mm and a square mesh panel with a minimum mesh size of 100 mm.
6. A prohibition of the use of strengthening bags in the Celtic Sea except for vessels targeting Nephrops.

Table 6.1 Summary of EU and UK measures in operation in the Celtic Sea (revised from STECF PLEN 21-02).

Technical measures applicable in UK waters of Celtic Sea. Applicable to UK and foreign vessel licences in UK waters. Applicable to Demersal otter trawls and seines (not beam trawls). Entered in to force September 5th 2021.			
Area	**Measures applicable in UK waters**	**Existing EU measure(s)**	**Effectiveness**
UK outer CSPZ*	Baseline mesh size 100 mm codend with 100 mm SMP	Baseline codend mesh size 100 mm in ICES 7b-k with derogations for smaller mesh sizes for directed fisheries (Annex VI, Part B, section 1.1 of EU 2019/1241 (TM)).	Derogated smaller mesh sizes prohibited. Likely to increase selectivity for cod and whiting.
UK outer CSPZ * - 7e East of 5° West only	Baseline mesh size 100 mm codend no SMP required	Baseline codend mesh size 100 mm in ICES 7b-k with derogations for directed fisheries (Annex VI, Part B, section 1.1 of EU 2019/1241 (TM)).	Effectively no change in selectivity for cod and whiting.
UK inner CSPZ**	Baseline mesh size 110 mm codend with 120 mm SMP	Within EU Inner Celtic Sea Protection Zone (CSPZ*) article 15 of EU 2021/92 (TAC) applies and includes four technical measures for cod and whiting: - 110 mm codend with 120 mm SMP - 100 mm T90 codend - 120 mm codend - 100 mm codend with 160 mm SMP Vessels with catches ≥ 20 % haddock must also have one metre spacing between fishing line and ground gear.	No. of available gear options reduced for EU vessels. Removal of requirement for raised fishing line where catches ≥ 20 % haddock is likely to negatively affect selectivity for cod and whiting (McHugh et al., 2019).
EU outer CSPZ*	EU rules to be followed	No change	No change
EU inner CSPZ**	EU rules to be followed	No change	No change
General fishing gear rules			
UK Outer CSPZ*	Maximum twine thickness: 4mm double; 6mm single	Maximum twine thickness: 4mm double; 6mm single	No Change

		(Article 3(a) EC 494/2002 (hake) applies in 7b-k)	
UK Outer CSPZ*	Strengthening bags prohibited except for vessels targeting *Nephrops*	Article 6 of EEC No 3440/84 (net attachments) applies and permits the use of strengthening bags under certain conditions	Likely to increase codend selectivity for cod and whiting.
Derogations			
UK Inner CSPZ	*Nephrops* catch threshold moves to 5 % while in EU waters threshold is 30 % under EU 2021/92. Changes to *Nephrops* gears proposed and undergoing consultation.	*Nephrops* measures include the Seltra Panel, Sorting Grid, Netgrid and SepNep (latter two as legislated in the North Sea). Also proposed to remove strengthening bags on Nephrops codends.	Discussion of threshold effectiveness to be dealt with separately. Removal of strengthening bags on *Nephrops* codends likely to improve selectivity for whiting and cod but also likely to result in a reduction in catches of Nephrops which could lead to more effort.
UK 7f East of 5° West	80 mm codend with a 120 mm SMP provided catches < 10 % of gadoids (cod, haddock and saithe)	Under EU 2021/92 (fishing opportunities) 80 mm only permitted for vessels catching *Nephrops* (30% threshold). Article 15 of EU 2021/92 (TAC) applies and includes technical measures for cod and whiting ·110 mm codend with 120 mm SMP ·100 mm T90 codend ·120 mm codend ·100 mm codend with 160 mm SMP Vessels with catches ≥ 20 % haddock must have one metre spacing between fishing line and ground gear.	Area largely within 12 nm of UK baseline. Reduction in codend mesh size and removal of raised fishing line requirement likely to reduce selectivity for whiting and cod.
UK Inner CSPZ**	Vessels with catches > 55% whiting or > 55% hake, angler and megrim combined may use a 100 mm codend with a 100 mm SMP.	Vessels with catches comprising > 55% whiting or 55% anglerfish, hake or megrim combined must use 100 mm codend with a 100 mm SMP.	No difference.
Derogations pending ongoing scientific assessments			
UK 7f within 12 nm and parts of UK 7e West of 5°W (ICES statistical rectangles	100 mm codend without a square mesh panel, provided that a single twine of 5mm thickness is used	In 7f article 15 of EU 2021/92 (TAC) applies and includes technical measures for cod and whiting:	UK 7f within 12 nm of UK baseline. ICES statistical rectangles 28E3 and 28E4 are

28E3 and 28E4)		· 110 mm codend with 120 mm SMP · 100 mm T90 codend · 120 mm codend · 100 mm codend with 160 mm SMP Vessels with catches ≥ 20% haddock must have one metre spacing between fishing line and ground gear. 6mm single twine or 4mm double twine can be used. In 7e West of 5°W. The gear implemented by the UK may be used by EU vessels provided catches < 1.5% of cod as assessed by STECF.	entirely in UK waters and a large proportion are within 12 nm of UK baseline. Reduced number of options for EU vessels. Removal of requirement for 120 mm SMP and raised fishing line likely to reduce selectivity for whiting and cod. Reduction in twine thickness likely to increase selectivity for whiting and cod.
UK 7e within 12 nm belt	80 mm codends provided vessels ≤ 12 m LOA or with an engine power ≤ 221kW with technical measures in 1241/2019		UK 7e within 12 nm not accessible to EU vessels.
* Outer Celtic Sea Protection Zone (CSPZ): 7f, 7g, 7h, 7j, 7k and UK 7e			
** Inner Celtic Sea Protection Zone (CSPZ): ICES divisions from 7f, 7g, the part of 7h North of latitude 49° 30' North and the part of 7j North of latitude 49° 30' North and East of longitude 11° West			
Sources: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1015122/07_-_2021_GN_-_Celtic_Sea_-_Demersal_towed_gears_v3.1.pdf; https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/950155/08_-_2021_GN_-_Celtic_Sea_-_Nephrops_V1.pdf			

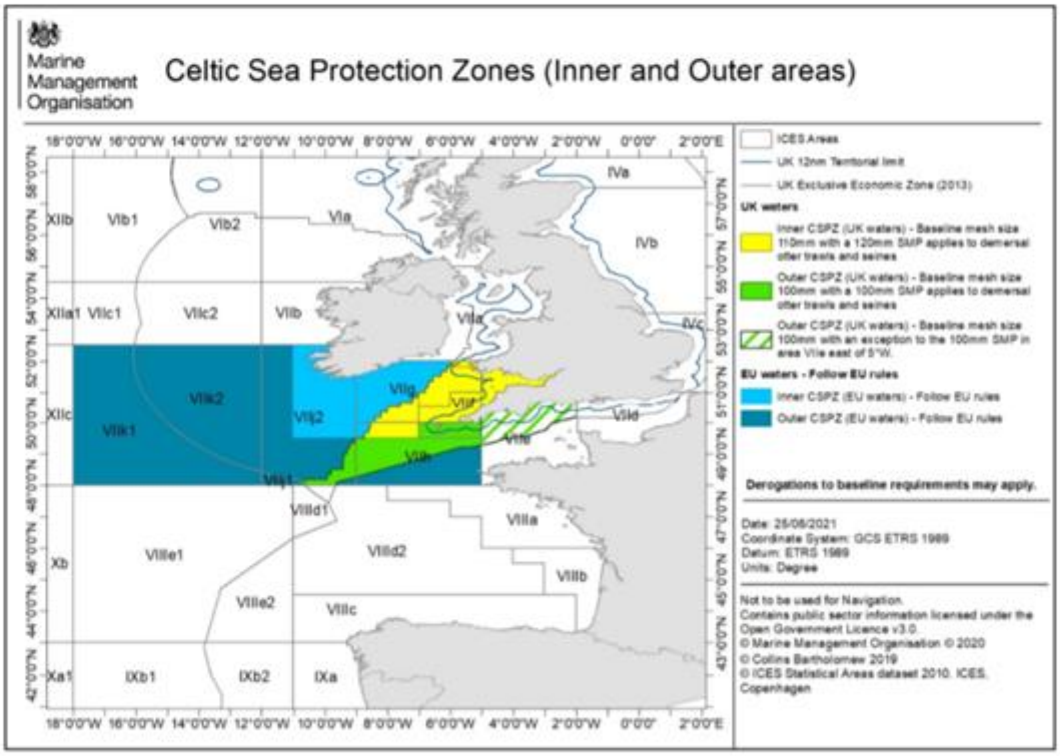

Figure 6.1. Definition of Celtic Sea Protection Zones according to the UK Marine Management Organisation, 2021.

6.1 EWG 21-18 Observations

6.1.1 Default mesh size of 110 mm and 120 mm square mesh panel

STECF PLEN 20-01 provided selectivity estimates for the four gear options included under the EU legislation (Article 15 of Regulation (EU) 2021/92) that can be used in the Celtic Sea Protection Zone. These gears are:

- 110 mm codend with 120 mm SMP.
- 100 mm T90 codend.
- 120 mm codend.
- 100 mm codend with 160 mm SMP.

PLEN 20-01 concluded that the 100 mm T90 codend was the least selective codend for all four of these species (cod, haddock, whiting and plaice). For cod, the next best is the 120 mm diamond mesh codend, and the most selective is the 110 mm diamond mesh codend with a 120 mm SMP positioned at 9 to 12 m. Unfortunately, STECF did not have any reliable estimates for cod selectivity in the 100 mm diamond mesh codend with a 160 mm SMP. There was little difference in the selective performance for haddock and whiting of the 120 mm diamond mesh codend and the 110 mm diamond mesh codend with a 120 mm SMP positioned at 9 to 12 m. The 100 mm codend with the 160 mm SMP is the most selective for haddock and whiting. For plaice, which STECF assumed will not escape through an SMP in the upper sheet of the extension at a position 9 to 12 m from the codline, the L50 increases with codend mesh size. The results are summarised below in Table 6.2.

Table 6.2.

Gear Type	cod		haddock		whiting		plaice	
	L50	SR	L50	SR	L50	SR	L50	SR
D110_P120	41.8	8.9	36.4	8.7	42.3	12.1	24.5	2.6
T90_100	36.2	6.1	32.9	5.9	38.2	10.9	17.9	2.0
D120	39.4	8.4	35.9	6.0	41.7	11.9	26.4	2.6
D100_P160			38.7	15.0	52.2	13.5	22.6	2.6

Under the UK measures introduced, three of the four gear options have been removed as legal gears that can be used in UK waters. Based on the analysis carried out by PLEN 20-01, EWG 21-18 acknowledges that the 110 mm and 120 mm SMP option is the most selective of these gear options for cod, haddock and whiting, noting that PLEN 20-01 advised that these results are estimates from different models and datasets so should be treated with caution. However, the analysis of STECF demonstrates that the other gear options available in EU waters are still highly selective compared to the baseline measures under the Technical Measures Regulation (Regulation (EU) 2019/2141). In all cases the L50s for cod, whiting and haddock are well above the legal MCRS. Therefore, the UK measures simply reduce the number of options available to EU fishers operating in UK waters, removing the degree of flexibility afforded in the EU legislation. Widespread use of the 110 mm and 120 mm smp over time may lead to improvements in selectivity for cod, haddock and whiting in the Celtic Sea Protection Zone. However, the rationale put forward by the UK that the gear options are unproven to deliver selectivity benefits is unfounded. The 120 mm codend mesh size has been used throughout the North Sea in gadoid fisheries and is thoroughly tested. The other gear options – 100 mm T90 and 100 mm with 160 mm square mesh panel – have been tested by Ireland (Oliver et al., 2020) and France (Rimaud et al., 2020). These trials have provided additional selectivity information for cod, haddock and whiting in comparison with 100 mm and 120 mm codends (see section below for more information).

6.1.2 Removal of the requirement to use the raised fishing line gear

The UK has removed the requirement to use the raised fishing line when catches are in excess of 20% of haddock. The raised fishing line is defined in article 15 of Regulation (EU) 2021/92 as a "fishing gear that is constructed with a minimum of one metre spacing between the fishing line and ground gear". The rationale provided by the UK for the removal of the raised fishing line is that for a selective gear to be effective, it must balance whether a fishery can continue to operate economically with the selectivity benefits it generates. Further, the UK observed that having the use of a selective gear dependent on meeting catch thresholds can reduce the uptake of those gears and may encourage discarding. However, recognising the potential benefits of the raised fishing line and gear such as the large mesh Eliminator trawl and Orkney Excluder Trawl, the UK indicated that they could in future be made a condition for access to fishing areas with the highest cod catches, where the benefits can be more easily assessed.

Based on the previous analysis by STECF PLEN 20-01. The raised fishing line trawl design is likely to reduce cod catches in targeted gadoid fisheries. This is based on the limited trials carried out in Ireland (McHugh et al., 2017, 2019) and Denmark (Krag et al., 2014), current understanding of fish behaviour and inference from other trawl designs. PLEN 20-01 showed that the Celtic Sea gadoid fishery will potentially reduce the L50 for cod and whiting by between 2.2 and 2.8 cm respectively. It also decreases retention of whiting less than about 35 cm but has very little effect on haddock as most haddock that escape under the fishing line are generally small and would have escaped through the codend if they had entered the gear.

However, PLEN 20-01 noted that the raised fishing line gives rise to substantial reductions of species such as lemon sole, plaice, monkfish, megrim and skates and rays where gadoids represent only a small bycatch. Therefore, EWG 21-18 suggests that the use of the raised fishing line and alternative gears giving similar catch profiles should be concentrated in the gadoid fishery and not in more mixed demersal fisheries where catches of cod and whiting are much lower. In this regard, PLEN 20-01 considered a range of alternative gear types as follows:

- Large mesh trawls (e.g., "Eliminator trawl", Orkney Excluder Trawl)
- Square mesh panels
- Sorting grids

STECF concluded that very few of these alternative designs will reduce catches of cod and whiting while maintaining catches of other species similar to the raised fishing line gear. The large mesh designs (Eliminator trawls and trawls with panels of large mesh) have been proven successful at reducing cod and maintaining catches of haddock and whiting but lead to reductions of flatfish and monkfish. Sorting grids and square mesh panel designs that reduce bycatch of cod, are also likely to reduce catches of haddock and whiting. EWG 21-18 considers this conclusion remains relevant, noting there is little new information relating to the effectiveness of these gears.

Regarding the removal by the UK of the 20% haddock threshold linked to the raised fishing line gear, EWG 21-18 observes that based on the threshold analysis carried out in TOR 1.2 of 2017-2019 data, some 1805 trips by 208 vessels recorded a catch of haddock greater than 20%. These trips caught 547 tonnes of cod out of a total cod catch of 2631 tonnes. Only French and Irish vessels are impacted. While it is not clear as to the number of trips inside and outside UK waters, the threshold analysis suggests that quite a considerable number of trips where the raised fishing line should be used will no longer be subject to this restriction in UK waters. This may lead to increased cod catches given that the default gear option in UK waters of the 110 mm codend with 120 mm square mesh panel is less selective for cod than the raised fishing line gear.

6.1.3 Default mesh size of 100 mm and 100 mm square mesh panel in ICES divisions 7e and 7h within UK waters

The UK rules allow for the use of 100 mm codend and 100 mm SMP with otter trawls and bottom seines in the "outer CSPZ" zone (Figure 6.1) within UK waters (ICES division 7e and 7h). Part of 7h (29E1, 29E2) and 7e west of 5°W (29E3, 29E4) are included in the scope of article 15 of Regulation (EU) 92/2021. The other part is not covered by article 15 and, therefore, has not been considered by EWG 21-18.

Assessing whether the default 100 mm and 100 mm smp gear represents an increase or decrease in selectivity compared to the EU legislation is complicated. This gear combination is included as a gear option under the *Nephrops (30%),* whiting (55%) and megrim, monkfish and hake (55% combined) derogations in the EU for the whole of the area covered by article 15. However, in the specific area defined by this provision under the UK rules, its use is not linked to a specific catch threshold. Therefore, depending on the catch composition, EWG 21-19 considers that it would either be equivalent in cases where the *Nephrops*, whiting and megrim, monkfish and hake thresholds are met or would represent a decrease in selectivity if catches contained significant quantities of haddock and cod requiring the use of the other gears listed in article 15 (i.e. 120 mm, 110 mm and 120 mm smp, 100 mm and 160 mm smp and 100 mm T90).

EWG 21-18 is unable to evaluate whether the latter case resulting in lower selectivity would be a frequent occurrence in the relevant areas. However, EWG 21-18 notes based on the spatial analysis carried out under TOR 2, the distribution of cod was quite high in ICES rectangle 29E3 during the period 2017-2019. The historic survey data from Armstrong et al., 2007 from the UK Fisheries Science Partnership western cod surveys in February – March 2004, 2005 and 2006 shows a similar high distribution of cod in 29E3. Therefore, EWG 21-18 observes that this measure has the potential to impact on cod catches, given the gear has a lower L50 for cod than other gears that would have to be used under the EU legislation.

6.1.4 Difference in the *Nephrops* catch threshold

Under Regulation (EU) 2018/2034 (NWW discard plan) from 1st of January 2019 the catch threshold defining the *Nephrops* fishery was amended from 30% under the old technical measures Regulation (Regulation (EC) 850/98) to 5% under the discard plan. This was then changed back to 30% subsequently under Regulation (EU) 2021/92 (fishing opportunities Regulation) from 1st January 2021 as part of the revised remedial measures for the Celtic Sea. The catch threshold for *Nephrops* is linked to the use of a range of gear options. These gear options are the same for both in EU and UK waters and are as follows:

a) 300 mm square mesh panel with a cod-end of at least 80 mm mesh size; vessels below 12 meters in length over all may use a 200 mm square mesh panel.
b) Seltra panel.
c) Sorting grid with a 35 mm bar spacing.
d) 100 mm cod-end with a 100 mm square mesh panel; and
e) Dual codend with the uppermost cod-end constructed with T90 mesh of at least 90 mm and fitted with a separation panel with a maximum mesh size of 300 mm.

The potential impacts of the 5% and 30% thresholds were assessed by STECF PLEN 20-02 in the context of the NWW discard plan and the conclusions remain relevant for EWG 21-18. PLEN 20-02 noted that the higher 30% threshold means that fewer trips and vessels will fall into that category and potentially would be required to use a more selective gear. However, in the absence of detailed catch composition data by trip, STECF could not quantify how many trips and vessels would be potentially included in the category, and thus could not assess fully the expected impact of this 30% threshold compared to the initial 5%.

EWG 21-18 has assessed the differences between the thresholds in terms of the number of trips by EU vessels, number of EU vessels and associated catches of cod resulting based on data from the period 2017-2019 inside the Celtic Sea Protection Zone. This shows that there were 43% less trips, 14% less vessels with 54% less catch of cod associated with the 30% threshold compared to the 5% threshold as summarised in Table 6.3. This does not mean that all of the vessels used the *Nephrops* gear options, simply that THEY had a catch composition that met the different catch thresholds. However, it does show that cod catches reduce when *Nephrops* catch increases, suggesting the more directed the fishery is towards *Nephrops*, the lower the catch of cod.

Table 6.3.

	5% Threshold	30% Threshold	% Difference
Number of trips (2017-2019) impacted	5436	3115	-43%
Number of vessels	159	137	-14%

(2017-2019) impacted			
Catch in tonnes of cod (2017-2019)	886	404	-54%

Analysing the data by Member States, shows that Ireland has the highest level of activity in the *Nephrops* fishery (Table 6.4). The data shows a similar pattern that the higher the threshold the lower cod catch.

Table 6.4.

	France		Ireland		Spain		Belgium	
	5%	30%	5%	30%	5%	30%	5%	30%
Number of trips (2017-2019) impacted	416	69	5018	3046	1	0	1	0
Number of vessels (2017-2019) impacted	23	15	134	122	1	0	1	0
Catch in tonnes of cod (2017-2019)	291	11	595	392	1	0	0	0

This analysis confirms that based on historic data the reduced threshold does increase the number of trips and vessels that can avail of the *Nephrops* derogation and leads to a higher cod catch. However, the actual impact of the change in threshold in UK waters is not clear to EWG 21-18. Two scenarios are considered possible:

<u>Scenario 1 - No change:</u> The number of vessels targeting *Nephrops* under the EU 30% threshold does not change as these vessels are in compliance with both the EU and UK legislation so have no need to change their operations. Therefore, they have no need to adapt as the gear options under both legislations are the same. Additionally, given these gears are very much designed for *Nephrops* fisheries and are not well suited to targeting other species and that the *Nephrops* grounds are discrete, there is no incentive for other vessels to use the reduced in *Nephrops* threshold to target other demersal species with a smaller mesh size (i.e., 80 mm mesh size).

<u>Scenario 2 - Increase in the number of vessels in the *Nephrops* fishery</u>: The number of vessels availing of the *Nephrops* derogation increases as the reduced *Nephrops* threshold provides an opportunity to use the gear options allowable under the derogation rather than more selective gears in UK waters. Most of the other gear options under the *Nephrops* derogation (i.e., SELTRA trawl, sorting grids, dual codend) are *Nephrops* specific gears and there is no obvious incentive to switch to using them. Conceivably, fishers could switch to the 80 mm codend and 300 mm square mesh panel gear option to target mixed demersal species as opposed to using the 100 mm and 100 mm square mesh panel (55% whiting or 55% anglerfish, megrim and hake derogation) or the 110 mm and 120 mm square mesh panel (gadoids). However, this is dependent on a) there being sufficient quantities of mixed demersal species on the fishing grounds inside UK waters to make such a switch economically attractive; b) ease of compliance with the 5% *Nephrops* catch threshold. Further, EWG 21-18 notes that the 80 mm and 300 mm square mesh panel is in itself a selective gear with significant reductions of catches of whiting and haddock of 52% and 70% respectively observed in trials carried out by Ireland (BIM, 2014). Therefore, in effect, even if the number of vessels availing of the 5% threshold and using this gear option increased, the impact on selectivity would be marginal.

6.1.5 80 mm and 120 mm square mesh panel derogation

This derogation allows for the use of 80 mm codend and 120 mm smp with otter trawls and bottom seines with catches comprising less than 10% of gadoids in an area in ICES division 7f East of longitude 5° West. It was originally included under the NWW discard plan (Regulation (EU) 2018/2034) and applies exclusively within UK waters in a part of the Bristol Channel in ICS statistical rectangles 30E5, 31E5, 32E5, 32E65, 32E6, 31E7. It was included to accommodate a small number of inshore vessels fishing from UK ports fishing for a mix of quota and non-quota species, such as sole, squid, cuttlefish. EWG 21-18 notes that the derogation is entirely within UK waters and EU vessels do not have access to this area, so therefore cannot use this derogation.

The 80 mm and 120 mm gear is undoubtedly less selective than other allowable gears as shown in the table below. The values presented are estimates from the same model used by STECF PLEN 20-01. Based on the 2017-2019 data, the catches in the area covered by the derogation are very low with catches of cod, haddock and whiting (typically < 1%). However, EWG 21-18 does note that historic data from Armstrong et al., 2007 shows cod catches were observed in the UK Fisheries Science Partnership western cod surveys in February – March 2004, 2005 and 2006, particularly in ICES rectangle 30E5. There is historic data for whiting presented. Therefore, while catches of cod are low currently if there was increased abundance of cod in the area as indicated by the historic data from UK groundfish surveys then the derogation may impact on cod catches in the future.

Table 6.5. Selectivity parameters for 80 mm and 120 mm smp compared to 100 mm and 100 mm smp based on model estimates.

Gear	Cod	Haddock	Whiting
80 mm and 120 mm SMP	L50 28.6 SR 6.1	L50 25.6 SR 3.7	L50 29.7 SR 8.5
100 mm and 100 mm smp	L50 34.2 SR7.3	L50 30.6 SR 5.1	L50 35.6 SR 10.2

6.1.6 Prohibition on the use of strengthening bags

The UK measures introduced from the 5th September includes a general prohibition of the use of the strengthening bags, except in *Nephrops* and beam trawl fisheries. Strengthening bags are placed outside the codend to protect it from damage from the seabed. This measure has general effect for demersal towed gears (trawls and seines) within UK waters of the Celtic Sea Protection Zone (7f, 7g, that part of ICES division 7h which is north of latitude 49° 30' North and that part of ICES division 7j which is north of latitude 49° 30' north and east of longitude 11° west) and UK waters of 7e (western Channel).

Kynoch et al. studied the effect of strengthening bags on the codend selectivity of Scottish trawls and found that the L50 of haddock increased by ~ 6% by removing strengthening bags (Table 6.6) with no change in selection range (SR). The codend mesh sizes tested, 100- and 120-mm diamond mesh, are applicable to those in place in the Celtic Sea and while results were only presented for haddock it is reasonable to consider that the prohibition on use of strengthening bags is likely to increase codend L50 for cod, haddock and whiting in the Celtic Sea.

Table 6.6. Results of Scottish trials to test the effect of strengthening bags on codend selectivity (Kynoch et al., 2004).

Codend	Haddock L50 (cm)	Haddock SR (cm)	L50 % increase
110 mm codend	29.5	4.5	
110 mm codend without strengthening bag	31.4	4.5	6.4%
120 mm codend	32.4	5.2	
120 mm codend without strengthening bag	34.3	5.2	5.9%

EWG 21-18 is not aware of the number of EU vessels impacted by this measure as there is no quantitative information on the use of strengthening bags across the EU fleet. Anecdotal information from industry sources suggests that Irish, French and Spanish vessels targeting mixed demersal species do not widely use strengthening bags, tending to use chafing gear. Therefore, the measure will not necessarily impact on EU vessels. However, Irish vessels targeting *Nephrops* routinely use strengthening bags, as do beam trawl vessels.

6.1.6 Future measures being considered by the UK

In July 2021, the UK Government launched a public consultation on Celtic Sea *Nephrops* directed fisheries technical measures, which may lead to new measures in UK waters in these fisheries. The consultation focused on the following:

- Selectivity device options – removal of two gear options – 300 mm square mesh panel and dual codend - currently included in EU legislation

- Prohibition of Strengthening Bags – Prohibition of strengthening bags in *Nephrops* fishery

- Percentage catch composition threshold required to define a '*Nephrops*-directed fishery' – Modifying the current 5% catch threshold in UK waters. The consultation suggests the catch threshold could be increased to 15% or 30%.

EWG 21-18 observes that were these measures to be introduced in UK waters, they would require further adaptation by EU vessels and in particular for Irish *Nephrops* vessels that have the highest catches of *Nephrops* in the Celtic Sea Protection Zone. The 80 mm with 300 mm square mesh panel and strengthening bags are used routinely by many Irish *Nephrops* vessels. Such measures were they to be introduced would impact on French, Irish, Belgian and Spanish trawlers and seiners operating in UK waters.

The potential for improved selectivity options for the beam trawl segment operating in all areas (ICES Area 7efghjk) is also under consideration by the UK. No detail has been provided of the measures being explored but if introduced may impact on beam trawlers from Belgium and Ireland.

The UK has also proposed the implementation of spatial measures to protect cod stock in specific areas of the Celtic Sea with the highest concentrations of cod landings which straddle the boundary between UK and EU waters. Based on data from the period 2015 to 2019, the UK observe that the ICES rectangles in the Celtic Sea with the highest cod catches are 29E1, 31E2 and 31E3. The UK suggest that a requirement to use enhanced technical measures (e.g., eliminator trawls, raised fishing line trawls) in these locations has the potential to substantially reduce the overall level of cod catches. The UK proposes two potential management actions which could be applied to these defined hotspots. The first would be to prohibit fishing by bottom trawlers and seiners outright. The second option could see the use of only highly selective cod gears.

In their document of September 2021 (MMO, 2021), the UK indicated that are considering two new derogations pending ongoing scientific assessment of the use of lighter twine in inshore fisheries as follows:

- Vessels operating demersal trawls and seines in the 12 nautical mile belt of 7f and ICES rectangles 28E3 and 28E4 of 7e, may use a codend of 100 mm without a square mesh panel, provided that a single twine of a 5mm thickness is used.
- Vessels of 12 m overall length or less with an engine power of 221 kw or less may fish with 80 mm codends within the 12 nm belt east of 5°W in ICES 7e. When using 80 mm codends under this derogation vessels must comply with the technical conservation rules set out in regulation 1241/2019 when fishing for sole and non-TAC species with 80 mm gear, and an 80 mm square mesh panel must be fitted.

These derogations would apply exclusively within UK waters where EU vessels have no access. The derogated requirement to use 5 mm single twine represents a reduction from the baseline single twine diameter of 6 mm within the wider Celtic Sea. Evidence exists that smaller diameter twine results in increased codend selectivity compared with thicker diameter twine (Kynoch et al., 1999; Lowry et al.,1996; Sala et al., 2007) so in this regard, this is positive from a selectivity perspective, noting that part of this area is outside the Celtic Sea Protection Sea Zone. The second derogation applies completely outside the Celtic Sea Protection Zone so is not relevant.

6.2 Additional Studies

EWG 21-18 is aware of several studies that have been carried out during 2020 that have looked at alternative gear options, as well as providing additional information on several of the existing gear options included under article 15 of Regulation (EU) 2021/92. All of these trials have been hindered by the lack of cod catches to provide statistically significant results. This makes it difficult to infer any conclusions on the impact of cod from the use of these gears. The results of these trials are summarised below.

6.2.1 Spanish Trials in 2020

Spain has undertaken additional selectivity studies to reduce gadoid catches in NWW. Information from RAPANSEL selectivity trials information is available from Spain as reported by Velasco et al., 2020. This study was carried out by IEO, onboard a 35 m single-rig vessel targeting megrim and anglerfish in ICES Division 7j. The trial was carried out as a catch comparison using single trawl and the alternate tow method. The control gear was a 100 mm codend, the baseline codend mesh size for ICES subareas 7b-7k under Regulation (EU) 2019/1241. Test gear was a experimental codend of 80 mm diamond mesh equipped with a 3-metre-long panel of 180 mm square mesh size (T0_80_T45_05_180 or D80_P180), positioned in the top sheet, 5 metres away from end of codend (instead in the extension as regulatory). A total of 171 valid hauls were completed for the trial (177 hauls in total) over 27 fishing days.

Table 6.7 presents percentages of difference in catch for test gear (D80_P180). The results in test gear shows reduction of cod, haddock and hake catches compared with the control gear (Velasco et al., 2020).

Table 6.7.

Species		Commercial	Unwanted

Cod	*Gadus morhua*	-6.023432541	-30.31
Haddock	*Melanogrammus aeglefinus*	-70.2468097	-53.53
Megrims	*Lepidorhombus* spp	11.99268421	-36.77
Anglerfish	*Lophius* spp	12.75428547	-29.37
Hake	*Merluccius merluccius*	-54.98461242	-25.65

The data obtained in this trial (RAPANSEL20) indicated that a fraction of unwanted catch of gadoids escaped through the square mesh panel in the codend. The comparison with control gear catch indicates a reduction of unwanted catch of cod and haddock (non-quota species) using the experimental codend D80_P180 were as follows:

- Cod decreased by 30.3% (2.4 kg/haul)
- Haddock decreased by 53.5% (23.7 kg/haul)

These results indicate that there is a decrease of catch for gadoids (in this case cod, haddock and hake). Spain has no quota for cod and haddock, so these are potential 'choke species' in this Spanish fishery (total of 12 vessels in 2020 targeting bottom species (i.e., megrim and anglerfish).

That gear combination tested (D80_P180) could be a possible solution for reducing the discard rates of juveniles of the target species and also several unwanted species in the fishery such as cod and haddock, thus minimizing the economic loss of the fishery using other optional gears.

6.2.2 French Trials in 2020

EWG 21-18 are also aware of work carried out by France. These trials were carried out by Ifremer in collaboration with Les PÊCHEURS DE BRETAGNE and COBRENORD as primarily a catch sampling trial followed the Obsmer protocol rather than as a dedicated selectivity trial.

Three of the four gears that are legal under EU legislation – 110 mm with 120 mm square mesh panel, 100 mm with 160 mm square mesh panel and 120 mm codend - for bottom trawlers and seines in the Celtic Sea Protection Zone (7f, 7g and 7h north of 49° 30'N and 7j north of 49° 30 N and east of 11° W) under EU 2021/92 were tested (Table 6.8).

The fourth option, T90 100 mm codend, was not tested as it had been the subject of previous work by the French authorities and is reportedly not widely used by French fishers.

The trials were carried out as a catch comparison using single trawls and the alternate tow method. The control for all three trials was a 100 mm codend, the baseline codend mesh size for ICES subareas 7b-7k under Regulation (EU) 2019/1241.

Temporal and spatial differences were minimised between pairs of alternate hauls and the proportions retained at length were modelled using a generalised linear model (GLM).

All three gears tested reduced cod catches compared with the control gear. However, the reductions in cod catches were not significant with any of the gears. The number of cod caught during all of the trials was very low and did not allow the reduction to be quantified in a meaningful way. All three devices also reduced whiting catches. The reduction in whiting catches were significant using the 110 mm with 120 mm SMP and 100 mm with 160 mm SMP devices but not with the 120 mm codend. Haddock catches were also reduced significantly with 100 mm with 160 mm SMP and 120 mm but not with the 110 mm with 120 mm SMP. The majority of cod, whiting and haddock caught during these trials with control and test gears were greater than MCRS. The low number of cod caught during these trials is symptomatic of a low abundance bycatch species.

Table 6.8. Description of the results from the trials carried out by Ifremer in collaboration with Les PÊCHEURS DE BRETAGNE and CO-BRENORD.

Test gear	Control gear	No. of trips	No. of hauls	Trial duration	Trial location (ICES statistical rectangles)	Trawl gear
100 mm codend with 160 mm square mesh panel	100 mm codend	2	32	12/9/2020 to 26/9/2020	26E3, 26E4, 27E3, 27E4	Single trawl, 34 m footrope, ~ 8 m vertical opening
110 mm codend with 120 mm squares mesh panel	100 mm codend	3	64	23/8/2020 to 21/9/2020	28E4, 28E5, 27E3	Single trawl, 28 m footrope, ~ 5 m vertical opening
120 mm codend	100 mm codend	1	16	7/10/2020 to 17/10/2020	29E3, 29E4, 30E3	Single trawl, 28 m footrope, ~ 5 m vertical opening

6.2.3 Irish Trials in 2020

Raised Fishing Line Trials

Ireland has undertaken additional studies into the raised fishing line gear. The study was carried out by BIM in Ireland, onboard the MFV Foyle Warrior, a 25 m single-rig vessel targeting mixed-demersal fish species in ICES Divisions 7g and 7j in the Celtic Sea between 19th – 23rd April 2021. The trials were carried out as a catch comparison using single trawls (620 X 80 mm fishing circle and ~ 5 m vertical opening) and the alternate tow method. Both the control and test gears were fitted with a raised fishing line (1m gap between ground gear and fishing line) and the test gear was fitted with lights. The raised fishing line was configured in a similar manner to McHugh et al. (2019) but chain was used to construct the 1 m long droppers instead of combination rope, and additional flotation was added to the fishing line to counteract the weight of the chain. McHugh et al. (2019) used an 80 mm codend with 120 mm square-mesh panel (SMP) in line with legislation at the time while in this study a 110 mm codend with 160 mm SMP was used in line with current regulations.

Two types of green-LED lights were tested in line with previous studies using artificial light at the mouth of the trawl (O'Neill and Summerbell, 2019; Hannah et al., 2015; Lomeli et al., 2018; Lomeli et al., 2020).

Directional lights were supplied by Safetynet Technologies (SNTECH). The SNTECHs have a depth rating of 200 meters, are rechargeable, emit light at a maximum brightness of 80 lumens and the batteries last up to 60 hours at the brightest setting.

More omnidirectional lights were also tested. Lindgren Pitman (LP) 'electralume' lights have a depth rating of 850 meters, emit 0.5 – 2 lux and the battery lasts up to 350 hours. Comparison of these different light intensities is not straight forward but the SNTECHs are likely brighter than the LPs.

Three separate trials were completed with 10 lights mounted ~1.5 meters apart on the fishing line (Figure 6.2):

- Trial 1 deployed SNTECHs pointing upwards away from the escape gap and towards the trawl mouth.
- Trial 2 deployed SNTECHs pointed downwards towards the escape gap and away from the trawl mouth.
- Trial 3 deployed omnidirectional LPs which likely illuminated an area around the fishing line.

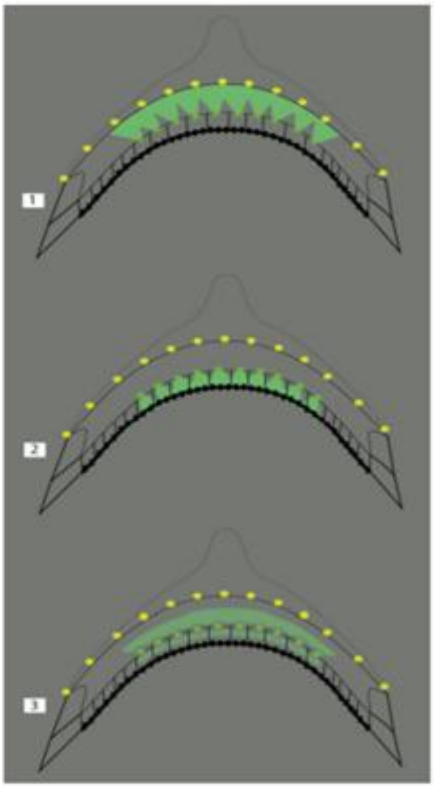

Figure 6.2. Light configuration Trials 1, 2 and 3 with lights on the RFL.

A total of six valid hauls were completed for each trial (18 hauls in total) over 5 days. Mean haul duration, towing speed, and depth fished during the study were 2 hr 58 min, 3.3 kt and 87 m, respectively.

In Trial 1, haddock catches were greatly reduced e.g., undersize haddock were reduced by 77% when the SNTECH lights were deployed pointing upwards. Whiting catches were low with little observed difference between gears.

In Trial 2, catches of haddock were substantially increased e.g., catches of undersize haddock were 84% greater when the SNTECH lights pointed downwards. Whiting catches were low but little difference occurred between gears.

In Trial 3, haddock were substantially reduced with LP lights on the fishing line (e.g., undersize haddock were reduced by 54%). Whiting catches were greater in Trial 3 compared with Trials 1 and 2 and were slightly lower in the RFL gear with lights (e.g., catches of large whiting were reduced by 31%).

Cod catches were low in all three trials and no inference can be made from the results.

Haddock, the main species encountered during the trial, clearly displayed a negative reaction to the lights. Substantially fewer haddock were caught with omnidirectional LP lights and with SNTECH lights pointing up towards the trawl mouth. Substantially more haddock were caught when SNTECHs were deployed pointing down towards the escape gap.

Whiting catches were generally low given the use of a 110 mm codend with a 160 mm SMP. Reasonable quantities of whiting were caught in Trial 3 where a small reduction in whiting occurred with LP lights deployed on the fishing line. These behavioural reactions to light are in line with preliminary findings from ongoing Scottish lab experiments which show a stronger reaction to light from haddock compared with whiting (*pers. comm.* Emma Mackenzie, Marine Scotland).

Very few cod were caught during the trial, likely partly due to the effectiveness of the raised fishing line as a cod avoidance measure and partly due to low abundance. The Scottish lab experiments have also noted a strong negative reaction from cod to light. This bodes well for further reductions in cod in the raised fishing line when they are more abundant on the fishing grounds.

100 MM T90 Trials

Ireland has also undertaken further work with the 100 mm T90 codend. Although this was carried out in ICES Divisions 7a (The Irish Sea), the results are relevant to the Celtic Sea given the similarities in the gears used and the catch composition. The trial was conducted on board a 22 m whitefish trawler in the Irish Sea, in March 2020. Catches were compared from alternate hauls using a 100 mm T90 mesh codend (T90 100), and a 120 mm diamond mesh codend (T0 120). A total of 14 valid hauls (7 with each codend) were carried out over four consecutive days.

Improved selectivity was demonstrated for haddock while equivalent selectivity. Haddock catch at length was small in both gears with a median length of 25 cm in T90 100 and 27 cm in the T0 120 or 25 cm combined. Moderate reductions (~ 40%) occurred in haddock < and ≥ MCRS in T90 100. These reductions were significant for haddock < MCRS of 30 cm, and for smaller market size haddock ~ < 40 cm but not significant for larger haddock. Substantial increases in plaice < and ≥ MCRS occurred in T90 100. A reduction in the value of smaller market sized haddock was offset by increased catches of flatfish species in the 100 mm T90 codend. The 100 mm T90 gear postponed choking and substantially increased total catch value under a monthly quota haddock scenario. For both cod and whiting, the number of fish retained was relatively low but showed equivalent catches in the 100 mm T90 codend compared with a 120 mm codend.

Future work planned

Ireland is planning to conduct a cod survival study in the Celtic Sea during Spring 2022. Due to their size and mobility, cod caught using demersal trawls or seines are unsuitable for on board or onshore monitoring of survival rates. Scope exists, however, to use popup satellite archival tags (PSATs) to monitor survival of cod which are returned to the sea. The PSATs will be deployed on cod to collect data and will pop off after a predetermined period of weeks, float to the surface and transmit data via satellite. Mark recapture tagging studies on cod have been carried out by the Irish Marine Institute in the past https://shiny.marine.ie/tagging/.

6.3 EWG 21-18 Conclusions

General conclusions

EWG 21-18 concludes that the measures introduced by the UK are likely to lead to relatively minor adjustments to exploitation patterns compared to the EU measures. However, they do reduce the level of flexibility that is afforded in the EU legislation in terms of the gear options fishers can use in certain fisheries. Additionally, they create difficulties for control given the differences in the rules between bordering areas.

Specific Conclusions

1. Default mesh size of 110 mm and 120 mm square mesh panel

EWG 21-18 concludes that the removal of the gear options included under EU legislation by the UK, reduces the flexibility afforded by the EU legislation to choose between a range of gear options. However, this does not necessarily reduce selectivity in the fishery for cod, haddock and whiting as the default gear selected by the UK is the most selective of the gear options included under the EU legislation. From an economic perspective, it may impact on EU fishers who choose to use some of the other gear options (i.e., 100 mm and 160 mm square mesh panel, 100 mm T90 and 120 mm codend) as they are more suited to their catch profile but without information on uptake of the different gear options by Member State, this cannot be fully assessed.

2. Removal of the requirement to use the raised fishing line gear

EWG 21-18 concludes that the removal of the requirement to use the raised fishing line in combination with the gear options listed and where catches are above 20% of haddock, will impact on the selectivity for cod and whiting. This gear has been demonstrated, albeit to a limited extent to reduce cod catches by the studies carried out by Ireland (McHugh et al., 2017 and 2019) and in Denmark (Krag et al., 2014). However, EWG 21-18 notes that the incentive to use this gear remains low given it reduces catch of other species such as monkfish and megrim and this is likely to be a barrier to its use. The reduction in the catches of other species associated with the raised fishing line is likely to make fishers more inclined to change catch profile to allow use of alternative gears (i.e., maintain catches below the 20% haddock threshold that triggers the use of the raised fishing line). In this regard, the proposal by the UK that suggests requiring the use of cod reducing gears in areas of high cod abundance may warrant further exploration.

3. Default 100 mm and 100 mm square mesh panel in ICES divisions 7e and 7h within UK waters

EWG 21-18 concludes that assessing whether the use of 100 mm and 100 mm smp in the relevant areas of 7e and 7h included under article 15 of Regulation (EU) 92/2021 represent an increase or decrease in selectivity is complicated. The UK has not linked the use of this gear option in the defined area to any specific catch threshold and in this regard differs from the EU legislation. However, EWG 21-18 notes based on the spatial analysis carried out under TOR 2, the distribution of cod was quite high in one ICES rectangle, 29E3 during the period 2017-2019. The historic survey data from the UK Fisheries Science Partnership western cod surveys in February – March 2004, 2005 and 2006 shows a similar high distribution of cod in 29E3. Therefore, EWG 21-18 concludes that this measure has the potential to impact on cod catches, given the gear has a lower L50 for cod than other gears that would have to be used under the EU legislation.

4. Difference in the Nephrops catch threshold

Based on the analysis carried out, EWG 21-18 concludes that, other than creating different rules between EU and UK waters, the actual impact from a selectivity point of view is likely to be marginal. It is unlikely that the numbers of vessels availing of the *Nephrops* derogation would increase as there is no real incentive to use the lower threshold for fishers to legally switch to less selective gear than would be otherwise required in mixed demersal fisheries in the Celtic Sea.

5. 80 mm and 120 mm square mesh panel derogation

EWG 21-18 concludes that while this derogation allows the use of a gear that is less selective than other legal gears in the Celtic Sea, it is confined to a relatively small area where the abundance of cod and whiting is low currently. However, EWG 21-18 does note that historic data from Armstrong et al., 2007 shows relatively high cod catches were observed in the UK Fisheries Science Partnership western cod surveys in February – March 2004, 2005 and 2006, particularly in ICES rectangle 30E5. Therefore, there is a possibility of increased abundance of cod in the area based on this historic survey data. If the UK were to extend this derogation to a wider area within the Celtic Sea Protection Zone or the abundance of cod in the area increased as observed historically, then the impact on cod and whiting stocks would increase, given this gear option is less selective than other gears used in the Celtic Sea.

6. Prohibition on the use of strengthening bags

EWG 21-18 concludes that based on limited selectivity data available, the prohibition of strengthening bags may have positive benefits in terms of improving selectivity for gadoid species. Anecdotal information from industry sources suggests this measure will not impact on EU vessels as their use amongst EU fishers is low.

7. Future measures being considered by the UK

EWG 21-18 notes that the UK is considering further technical measures, both gear-based and spatial measures. EWG 21-18 concludes that these measures if they come into force will impact on EU vessels across Member States. However, EWG 21-18 has not been able to assess the potential impacts to any degree.

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6 List of Annexes

Electronic annexes are published on the meeting's web site on:
http://stecf.jrc.ec.europa.eu/web/stecf/ewg2118

List of electronic annexes documents:

EWG-21-18 – Annex 1 – Partial F for the main species and for the main country – métiers.
EWG-21-18 – Annex 2 – Lpue maps and revenue maps (predicted rpue x fishing effort) by métier.
EWG-21-18 – Annex 3 – Spatio-temporal closures maps associated with species scenarios, and catch reduction scenarios.
EWG-21-18 – Annex 4 – DISPLACE model: scenario testing bio-economic impact of spatial management measures on Celtic Sea fisheries.
EWG-21-18 – Annex 5 – Bio-economic statitic analysis 1.
EWG-21-18 – Annex 6 – Bio-economic statitic analysis 2.Catch reduction.

7 List of Background Documents

Background documents are published on the meeting's web site on:
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List of background documents:

EWG-21-18 – Doc 1 - Declarations of invited and JRC experts (see also section XX of this report – List of participants)

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