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Scientific, Technical and Economic Committee for Fisheries (STECF) - Review of technical measures (part 1) (STECF-20-02)

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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 evaluates the performance of technical measures to conserve fishery resources and protect marine ecosystems in accordance with Article 31 of Regulation (EU) 1241/201.

SCIENTIFIC, TECHNICAL AND ECONOMIC COMMITTEE FOR FISHERIES (STECF) - Evaluate the performance of technical measures to conserve fishery resources and protect marine ecosystems according to Article 31 of Regulation (EU) 1241/201 (STECF-20-02)

Background provided by the Commission

According to Article 31 of Regulation (EU) 1241/2019 on the conservation of fishery resources and protection of marine ecosystems through technical measures, the Commission is required to report, following evaluation by STECF, on the extent to which technical measures both at regional level and at Union level have contributed to achieving the objectives set out in Article 3 and reaching the targets set out in Article 4 of Regulation (EU) 1241/2019. The first report is due to submitted on the 31 December 2020, with reports every three years thereafter.

To facilitate this, STECF is requested by the Commission to evaluate the performance of technical measures to conserve fishery resources and protect marine ecosystems. STECF should consider the following elements in their evaluation:

- selectivity improvements;
- innovative gears;
- catches of marine species below MCRS;
- incidental catches of marine mammals, sharks, reptiles, seabirds and other sensitive species;
- the impact of fishing activities on seabed habitats;
- the optimisation of exploitation patterns to provide protection for juvenile or spawning aggregations of marine resources;
- the minimisation and possible elimination of incidental catches of sensitive species (as defined in Article 6(8) of that Regulation); and
- minimising the environmental impacts of fishing.

Specific attention should be paid to areas where, at regional level, there is evidence that the objectives and targets as set out in Articles 3 and 4 of Regulation (EU) 1241/2019 have not been met.

STECF is also asked to advice on the most appropriate selectivity performance indicators for comparative evaluation of fishing gears according to Article 16 of Regulation 1241/2019. In preparing its advice, STECF shall inter alia consider the use of the length of optimal selectivity Lopt compared to the average length of fish caught. As part of its evaluation, STECF shall calculate historic time-series of the most appropriate indicator identified for each of the commercially exploited stocks where feasible.

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.
In this revision, STECF is requested to incorporate the latest ICES advice on innovative gears.

STECF comments

ToR 1-3 Selectivity performance indicator & assessing the impact of technical measures

Background – a brief overview of prior developments

Since 2012, STECF has considered a range of indicators for monitoring changes in selectivity and exploitation patterns during several STECF experts working groups (EWG 12-20, EWG 13-04, EWG 15-05 and EWG 17-02). This was in the context of the development of the Commission's proposal for a new technical measures framework and for monitoring and reporting on the Landing Obligation (EWG 13-23 and EWG 16-13). From the very beginning, the weakness of catch-based metrics was identified (due to their sensitivity to population structure) and 'pilot' indicators discussed were typically F-based (e.g. Fimmatures/Fmatures in STECF 12-20, STECF 13-04; Age at which F is 50% of maximum F-at-age in STECF 15-05).

Subsequently, the 2016 Commission's proposal for a new technical measures regulation introduced the concept of quantitative targets in line with CFP objectives as essential elements to support the implementation of technical measures. Accordingly, STECF 18-15 tackled the issue of selectivity indicators in a more systematic way by comparing a range of different catch-based, length-based and F-based indicators using both simulated and empirical data. Among other observations, this work illustrated that F-based indicators were the most informative of those investigated. The work within STECF 18-15 was later extended into a scientific publication (Vasilakopoulos et al. 2020), which identified the ratio Frec/Fbar, the ratio of the F of the first recruited age–class to the mean F of the fully exploited age classes, as being the most suitable selectivity indicator among those tested. In particular, it has the major advantage that unlike the other approaches tested in the publication, it can track selectivity changes, without being overly sensitive to changes in recruitment or changes in overall fishing pressure.

In addition, STECF PLEN 18-01 looked at the use of the length of optimal selectivity (Lopt) as a reference point against which to measure the impact technical measures have on the exploitation pattern of commercially exploited stocks. STECF underlined that improving this exploitation pattern is key to reduce the impact of fishing on the stock's biomass, and thus contributing to the objective of minimising the impact of fishing on marine ecosystems.

At the summer 2020 plenary meeting of the STECF (STECF PLEN 20-02), it was agreed that the EWG to evaluate the TMR would build on the work on age-based selectivity indicators initiated by STECF EWG 18-15 and further developed by Vasilakopoulos et al. (2020) and would also consider Lopt, building on work by ICES WKLIFE and others. Furthermore, because the number of EWGs was reduced from 2 to 1 and because of the need to seek further clarification from DG MARE on what would be required of the STECF and its EWG, further discussions were held throughout July within a group comprising participants from DG MARE, STECF Board, the EWG co-chairs and the JRC focal point. Part of this group's tasks was to issue the data request to ICES, to obtain time series of F-at-age per stock and fisheries in digital format.

STECF comments on ToR 1-3

The EWG was requested to evaluate the performance of technical measures according to Article 31 of Technical Measures Regulation (TMR) (EU) 1241/2019 (Item 1 of the ToRs) and the extent to which technical measures both at regional level and at Union level have contributed to achieving the objectives set out in Article 3 of said Regulation and reaching the targets set out in Article 4, including progress that has been made or impact arising from innovative gear (Item 2 of the ToRs). STECF notes that given that the TMR 2019/1241 has only been in place for one year, it is too soon to be able to evaluate (backward) any aspect of its performance with regard to achieving their stated objectives and targets. The evaluation task comprised, thus, ex-post investigation of the impact that previous technical measures have had on the stated objectives and targets.

The EWG 20-02 was also requested to advise on the most appropriate selectivity performance indicator for comparative evaluation of fishing gears according to Article 16 of Regulation 1241/2019 and where possible, calculate time-series of the appropriate selectivity indicator for each of the main commercial fish stocks and areas, considering those included in Annex XIV of the TMR (Item 3 of the ToRs).

In an attempt to address item 3 of the terms of reference as far as practically possible, time-series of the selectivity indicators for the main commercial fish stocks and areas were calculated using the method described in Vasilakopoulos et al (2020). STECF agrees that given the available data and resources and in the context of the advice provided by the STECF PLEN 20-02 and discussions between the STECF and DG MARE, such an approach was appropriate. Nevertheless, the approach did not allow the terms of reference to be addressed in their entirety, especially items 1 and 2. Additionally, although many technical measures relate to specific gears and/or fisheries, no fishery- or gear-specific evaluations were undertaken for stocks in different regions. Hence, the results presented in the EWG 20-02 report provide an overview of temporal trends in relative selectivity for the recruiting year-classes at the population level only.

In addition, the EWG raised concerns that the Vasilakopoulos et al (2020) approach is sensitive to estimates of F at age from stock assessments which can be rather uncertain. STECF agrees with the Expert group remark that F-at-age is often estimated with large uncertainty, particularly on the youngest ages, thereby making the Frec/Fbar indicator also uncertain. In addition, the choice of stock assessment model and the associated assumptions about selectivity will influence the resulting F-at-age from the assessment.

Other management measures may also affect the quality and reliability of the catch data which are fundamental to stock assessments and the resulting estimates of F-at-age, and especially Frec. In particular, the introduction of the landing obligation may have changed the willingness of the fishery to permit observers on board to collect catch samples which may lead to underestimates of undersized unwanted catch. Other changes that have occurred may also contribute to observed trends in selectivity such as the introduction of other management measures, quota changes, effort restrictions, changes in fishing behaviour and others.

Incidentally, STECF notes that there may be some inconsistencies in the lists of the technical measures identified by EWG 20-02 for the individual stocks, and highlights that these lists are not exhaustive. In some cases, the implementation dates relate to the date the specific regulations were introduced and do not necessarily take account any lead-in times included in the Regulations. Furthermore, the fact that technical measures are introduced does not necessarily mean that they will be implemented in full by the industry, which may mean that the intended effects on selectivity are not delivered.

As such, STECF notes the difficulty to fully interpret the observed trends. For those stocks where no changes were detected over time, the absence of change in indicator should not be seen as proof that the TM had no effect at all, but at least that the effects were not strong enough to be detected at population level by standard stock assessment procedures using standard data. For the stocks where changes in selectivity of recruiting year-classes appear to be coincidental with the timing of the introduction of certain technical measures, it remains difficult to ascertain that this change is caused directly by the introduction of the technical measure (Item 2 of the ToRs). The EWG could also, thus, not fully evaluate the performance of technical measures to conserve fishery resources and protect marine ecosystems according to Article 31 of Regulation (EU) 1241/201 (Item 1 of the ToRs).

ToR 1-3 Conclusions

1. Evaluate the performance of technical measures to conserve fishery resources and protect marine ecosystems according to Article 31 of Regulation (EU) 1241/2019.

The results of the investigations undertaken by the EWG 20-02 do not permit STECF to provide a comprehensive informed response to this request. The request is extremely wide-ranging in scope and to address it explicitly and provide an informed, meaningful response, will require far more time and expertise than that afforded to EWG 20-02 and to this STECF review.

Suggestions on what needs to be done to support the Commission to provide future reports to the European Parliament and the Council in accordance with Article 31 of Regulation (EU) 2019/1241 are given in the section below headed "Future Developments".

2. Evaluate the extent to which technical measures both at regional level and at Union level have contributed to achieving the objectives set out in Article 3 of said Regulation and reaching the targets set out in Article 4, including progress that has been made or impact arising from innovative gear.

The EWG 20-02 report provides informative overviews of temporal trends in selectivity for juveniles (recruiting year-classes) for selected species and regions, but the extent to which such changes can be attributed to implementation of technical measures cannot be deduced from the approach taken. For some stocks changes in selectivity of recruiting year-classes may be coincident with the timing of the introduction of technical measures. Even in such cases, however, it is not possible to ascertain whether the changes are directly due primarily to the introduction of technical measures or to a combination of technical measures and other factors (although the selectivity indicator is considered robust to variations in recruitment and in total fishing pressure). Hence, based on the work of the EWG 20-02, STECF can only partly provide an informed evaluation of the extent to which technical measures have contributed to the conservation of fishery resources and the protection of marine ecosystems.

Regarding the target set out in Article 4 that catches of marine species below the minimum conservation reference size are reduced as far as possible, STECF notes that the FDI EWG 20-10 has adopted a methodology to partition catches at age into numbers of fish above and below MCRS, and has applied it to all stocks and fisheries for which the relevant data are reported under the FDI data call, by country, year, area and métier and for the years 2015-2019. The EWG 20-10 was unaware of the availability of such data and analyses but STECF considers that the data may prove useful for future reviews and may also be informative to DG MARE in preparing its 2020 report to the European Parliament and the Council.

3. Advise on the most appropriate selectivity performance indicator for comparative evaluation of fishing gears according to Article 16 of Regulation 1241/2019. In preparing its advice, STECF may inter alia consider the use of the length of optimal selectivity Lopt compared to the average length of fish caught. Where possible, EWG 20-xx should calculate time-series of the appropriate selectivity indicator for each of the main commercial fish stocks and areas, considering those included in Anne XIV of the TMR.

A comprehensive investigation into the most appropriate selectivity performance indicator for comparative evaluation of fishing gears according to Article 16 of Regulation (EU) 1241/2019 could not be undertaken with the data and resources available at the time of the EWG. The suitability of using ratios such as Lmean/Lopt or Lc/Lc_opt[1] as the basis for such an indicator was not explored further.

The EWG was able to address the latter part of this request and provide time-series of trends in selectivity for juveniles for selected fish stocks and areas. Nevertheless, for several reasons as outlined above and in the EWG 20-02 report, especially those relating to estimating fishing mortality at age and the assumptions regarding selectivity at age in the assessment model, the results need to be interpreted with caution.

ToR 4 Innovative gears

STECF notes that in relation to item 4 of the terms of reference on innovative gears, the EWG only briefly referred to it as the ICES 2020 advice was only published in late October 2020 and thus not available at the time of the EWG meeting.

STECF notes that ICES (2020) defines "innovative gear" as a gear or a significant component of a gear that is different from the baseline in the current EU regulations or, in the absence of such legislation, different from the gear commonly used in a specific sea basin (area) in EU waters.

ICES developed a framework for assessing the performance of innovative fishing gear based on three assessment criteria: (a) catch efficiency, (b) selectivity on target species and reduction of catch of unwanted and incidental species, and (c) impacts on the ecosystem, evaluated on a relative scale (i.e. scored relative to the existing gear). For each criterion an innovation matrix was created, relating the potential performance improvement (disruptive, transformative, incremental, no effect or negative) and technology readiness level (low, moderate, high; columns) of innovative gears.

STECF notes that ICES then used the framework to create an initial catalogue of innovative fishing gears for EU fisheries. It contains 33 example factsheets that are indicative of gear innovations in different areas in EU waters, but it is not an exhaustive list. STECF acknowledges the interest of monitoring progresses with innovative gears being developed or used in EU waters and notes that additional information could be provided from projects such as Discardless (http://www.discardless.eu/), Minouw (http://minouw-project.eu/) and Gearing Up (https://gearingup.eu/). Additionally, STECF suggests that consideration be given to innovative technologies that are being developed in projects such as SmartFish 2020 (http://smartfishh2020.eu/) that also have the potential to improve selection, reduce bycatch and minimise the environmental impact of fishing gears.

STECF agrees with ICES that its advice is a first step into a longer time-frame process, where a more comprehensive review of gear innovations and their impacts could be provided to the EU on a triennial basis. STECF considers the framework developed by ICES is appropriate to assess the performance of innovative fishing gear. However, as recommended by ICES, further work should include the level of gear uptake by fishers and sociotechnical aspects associated with the innovation (financial aspects such as investments and cost reduction, user-friendliness, and health and safety) should be part of a comprehensive state-of-the-art review.

STECF notes that prior to future reviews of the TMR, there is a need to continue develop a comprehensive framework of criteria and methods for evaluating the extent to which the implementation of technical measures has contributed to achieving their stated

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[1] Lmean/Lopt is the ration of the current mean size and the optimal one, while Lc/Lc_opt is the ration of the current length at first catch to the optimal one

objectives and the wider objectives of the CFP. This framework should also be able to assess the potential for innovative gears to contribute to achieving such objectives.

From the perspective of scientific evaluation, it would also seem appropriate that regional fisheries bodies especially ICES and the GFCM in addition to the STECF become involved in such a process.

ToR 4 Conclusions

4. Assess the progress made or impact of innovative gear and evaluate the use of innovative gears, drawing conclusions about the benefits for, or negative effects on, marine ecosystems, sensitive habitats ***and*** *selectivity based on the most recent advice from ICES and other relevant scientific organizations.*

STECF concludes that the extent to which innovative gears can contribute to reaching the TMR objectives and targets depend on these being first taken up by fishers and adequately monitored during a sufficient time frame before they can be evaluated.

STECF concludes that the assessment framework developed by ICES for innovative gears would need to be combined with a holistic fishery simulation model to assess whether the potential improvements brought by the selective gears are likely to be of any significant effect at population level, considering the appropriate selectivity indicators.

ToR 5 Estimates of sensitive species by-catch rates

STECF notes that in response to item 4 of the terms of reference, the EWG 20-02 report includes an overview and a catalogue (excel file) of sensitive species compiled from different sources[2]. This list presents for each species where bycatch data exist and where it is lacking. The EWG report also includes an overview of mitigation measures aimed at protecting sensitive species. The EWG provides a direction for future work, including among others, measures such as an increase in monitoring (métiers, spatial and temporal coverage), species identification, abundance estimation and thresholds.

The EWG 20-02 report concludes that there is very limited data to reflect historic development in population size and/or bycatch of sensitive species and hence, whether the TMR objectives and targets regarding sensitive species have been or are being achieved, cannot be evaluated. However, the Expert group tried to make an inference of the impact of fisheries on sensitive species based on the historical trend of fishing pressure (based on the STECF CFP monitoring report (STECF 20-01) of the fisheries assessed as high risk of encountering and impacting sensitive species. Based on the FDI database and for the period 2015-2018, the Expert group report also present trends in fishing effort per region and in some regions by métier.

The EWG 20-02 analysis moves forward the work needed to evaluate the TMR objectives and targets in relation to sensitive species. However, STECF also notes that, as reported by the EWG, although bycatch mortality of sensitive species is likely to have decreased in Atlantic waters (including Baltic Sea) due to a decrease in fishing pressure (a general reduction in fishing mortality rates), this does not necessarily relate to changes in technical measures. In the Mediterranean no such effort reduction has been observed.

STECF further notes that estimating bycatch thresholds is not straightforward and estimates rely on several aspects including i) the conservation objectives and targets for the sensitive populations, ii) the timescale over which such objectives and targets are to be met and iii) available estimates of population size.

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[2] 2018 prohibited species list of the EU fishing opportunities regulation, Birds and Habitats Directives, IUCN red list, ICES WGBYC and WGBIODIV, OSPAR, GFCM, Barcelona Convention, CITES, etc.

STECF notes the EWG's comment on the need for effort data, specifically relating to fixed nets, to be used in stock assessments to determine species status. STECF underlines that many such data are available in FDI data set. Although not used by the EWG, STECF notes that data on fishing effort in the years prior to 2015 is still available from the old FDI data, and also reported in ICES fisheries overviews for the NorthEast Atlantic region, if the EWG's effort analysis was to be extended longer back in time.

ToR 5 Conclusions

5. Report on the best available estimates of sensitive species (incl. seabirds, sharks, turtles, cetaceans) disaggregated by species, fishery and Member State in relation to the conservation status of each species with an assessment whether by-catch rates are changing over time and to identify problematic fisheries that may require specific attention.

STECF concludes that the EWG 20-02 report documents the information requested to the extent possible. Based on numerous sources, the report lists sensitive species that are impacted by fisheries, identifies problematic fisheries and provides a preliminary assessment whether by-catch rates have changed over time. Nevertheless, significant knowledge gaps remain, notably in reliable population estimates for many species and areas. With future TCM reviews in mind, STECF recognizes the need to develop a more comprehensive methodology to evaluate and assess the impacts of fisheries on sensitive species.

STECF concludes mitigation measures to reduce sensitive bycatch are not straightforward, and the investigation of alternative options must continue to be sustained. Additionally, STECF notes that the degree of compliance in the uptake and use of existing mitigation measures in identified high risk areas and fisheries is unknown, and might need to be strengthened.

ToR 6 Impacts of fisheries on habitats

The EWG 20-02 highlights vulnerable marine ecosystems (VMEs) as the most sensitive habitats impacted by fishing, and points out that VMEs are defined by the 2009 FAO criteria and further qualified by thresholds specified by the 2020 ICES/NAFO Joint Working Group on Deep-water Ecology (WGDEC). The EWG report provides an overview of the information available to identify recovery of fished areas based on the work carried out by the ICES Working Group on Fisheries Benthic Impact and Trade-offs (WGFBIT) in the context of the reporting requirements under MFSD. STECF notes that as referenced by the EWG, ICES is currently assessing the impact of bottom-contacting gears within 5 ICES ecoregions. A review of existing areas closed to bottom trawling under the Habitats and MSFD is also presented in the report.

The EWG 20-02 reported on possible management measures for sensitive species and habitats, including the possible impact of innovative trawl gears with the potential to reduce benthic impact. STECF agrees with the conclusion of the EWG that the areas closed under the previous TMR or other EU regulations may have been effective in preserving some vulnerable ecosystems located in deep-sea areas, as the measures taken are straightforward by prohibiting the use of bottom contacting gears and some passive gears in these areas. However, STECF notes, as acknowledged by EWG 20-02, closed areas implemented to protect and rebuild commercial stocks can indirectly reduce the impact on seabeds and protect marine ecosystems, but only if the total spatial footprint of fishing is reduced.

ToR 6 Conclusions

6. Report on data on impacts of fisheries on habitats and ecosystems that help to identify areas where further efforts are needed to address adverse impacts on the sensitive habitats including vulnerable marine ecosystems (VMEs).

STECF concludes that the EWG provided the information requested on the impacts of fisheries on habitats to the extent possible given the available information and resources.

STECF notes however that objective 2(c) specified in Article 3 of the TCM Regulation (Regulation (EU) 2019/1241) states [Technical measures shall] "ensure, including by using appropriate incentives, that the negative environmental impacts of fishing on marine habitats are minimised;". This specific aspect of incentives was not addressed by the EWG 20-02.

STECF notes that there is a long debate regarding the 'positive' incentives in fisheries management to promote compliance. Appropriate incentives have the triple benefit of i) increasing the odds of reaching the objective (reducing the impacts on marine habitats), ii) increasing the "buy-in" of the regulation by the sector, and iii) reducing the cost of enforcing and controlling the regulations. STECF notes that there is however little knowledge of the incentive structure in the currently implemented measures under the new TMR, and that the monitoring of the achievement of this specific objective would require dedicated social and economic studies.

Overall conclusions on the EWG 20-02 report

The STECF commends the work undertaken by the EWG 20-02 in attempting to address extremely demanding terms of reference under difficult circumstances and with limited data and resources and endorses the findings given in the report.

STECF notes that it is too early to be able to assess any resulting effects of the measures in the TCM Regulation (EU) 2019/1241, even if a 'precise' indicator or metric to assess the effects of technical measures at the population level (?) were available.

Future developments

During its discussion on the outcomes of EWG 20-02, it became clear to STECF that there is still scope for interpretation of precisely what was being requested by the Terms of Reference which largely reflect the provisions of Article 31 of the TCM.

On one hand, Article 31 specifies inter alia that "*following an evaluation by the STECF, the Commission shall submit a report to the European Parliament and to the Council on the implementation of this Regulation*", which may mean an evaluation of whether the measures introduced by that Regulation are indeed being implemented as the Regulation intended, based on supporting evidence provided by Member States and the Advisory Councils.

On the other hand, Article 31 also specifies "*That report shall assess the extent to which technical measures both at regional level and at Union level have contributed to achieving the objectives set out in Article 3 and reaching the targets set out in Article 4*". However, given that the Regulation has been in force since July 2019, a scientific evaluation of the extent to which the provisions of the technical measures Regulation have contributed to the targets and objectives is not yet possible; sufficient data and information are simply not yet available to allow such an assessment.
Hence, an alternative interpretation of Article 31 could be to assess the extent to which technical measures in general, from Regulations (EU) 850/98 (NE Atlantic), (EU) 2187/2005 (Baltic TMR) and (EU) 1967/2006 (Med Reg) onwards, have contributed to achieving the objectives and targets of Regulation (EU) 2019/1241. This was the

approach followed by the EWG 20-02. However, discussions during PLEN 20-03 highlighted the ambiguity between backward-looking evaluations (ex-post) of historical technical measures, and forward-looking assessments (ex-ante) of Reg. 2019/1241.

Whichever is the intended interpretation, the EWG report does not provide all the information required for STECF to provide a fully comprehensive and informed response to all the terms of reference. Given that STECF will be requested to undertake an evaluation of the performance of the TCM every three years, some considerations on how to proceed in the future are provided below.

1. Define the scope for any future evaluations (e.g. is Article 31 specifically concerned with evaluating the performance of the measures in Regulation (EU) 2019/1241 in achieving the targets and objectives of that Regulation?).

2. Specify what is to be evaluated? From Article 31 it appears that evaluation of the performance of technical measures against objectives and targets is what is required, but given the diversity and number of fleets/fisheries and technical measures in different regions, it will be impossible to examine and assess each and every measure. Decisions need to be taken regarding which aspects of the TCM regulation and which fisheries are a priority bearing in mind the data and resources available as well as the nature and likely impacts of the different fleets/fisheries. The expectations of what STECF can deliver should be realistic and achievable and be able to inform against the targets and objectives. A way forward could be to assess the extent to which the targets set in the current regulation are being achieved, using a gear and area approach. This could provide a risk-based analysis, highlighting where more detailed assessment of the effects of the current TMR is a priority.

3. Regarding the most appropriate and informative indicators and metrics to use, discussions during PLEN 20-03 showed that there is still so far no single indicator to evaluate the full performance of technical measures, but different approaches used in complementarity may in the future provide a more holistic view of the paths towards the achievement of objectives and targets.

4. Which data sets are required to carry out the evaluations and who should provide this data?

5. In trying to assess the effectiveness of the measures included in the Regulation there is a need to assess the incentives for fishermen to adapt, adopt and buy-in to specific technical measures.

6. What is/are the appropriate forum/fora to undertake the evaluations? Would it be sensible to adopt a regional approach (i.e. different expert groups dealing with different regionally focused evaluations)?

7. Who should be involved? To evaluate the effects of technical measures requires knowledge of the regional fisheries, the stocks and the evolution of exploitation rates on the stocks and the extent to which various measures have been taken up in each region.

To address the above there is, firstly, a need to define the scope of future evaluations and to consider how best to convene a meeting involving the Commission, fisheries scientists gear technologists, data experts and regional fisheries experts (industry, academic, regional fisheries body or other expert disciplines).

STECF suggests that an initial discussion could take place in the December 2020 STECF Bureau meeting where the scope for future evaluations could be discussed. Once the scope is clearly defined, a decision needs to be taken on the appropriate way forward to address how best to plan for and carry out future evaluations to ensure that the Commission is furnished with the information to allow it to fulfil its obligations under Article 31 of the TCM regulation.

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REPORT TO THE STECF

EXPERT WORKING GROUP ON
Review of technical measures (part 1)
(EWG-20-02)

Virtual meeting, 5-9 October 2020

1. Executive summary

STECF EWG 20-02 has been requested by the Commission to evaluate the performance of technical measures to conserve fishery resources and protect marine ecosystems, to advise on the most appropriate selectivity performance indicators and to assess progress made in the context of reporting requirements required under Article 31 of Regulation (EU) 1241/2019 (technical measures framework regulation). Specifically, the EWG was requested to consider the following:

- selectivity improvements;
- innovative gears (e.g. pulse trawl);
- catches of marine species below MCRS;
- incidental catches of marine mammals, sharks, reptiles, seabirds and other sensitive species;
- the impact of fishing activities on seabed habitats;
- the optimisation of exploitation patterns to provide protection for juvenile or spawning aggregations of marine resources.

EWG20-02 was also asked to advise on the most appropriate selectivity performance indicators for comparative evaluation of fishing gears according to Article 16 of Regulation (EU) 1241/2019.

Based on previous work carried out by STECF EWG 18-16, the selectivity performance indicator used as the basis for the evaluation is the ratio of F of the first recruited age class (F_{rec}) to F_{bar} (F_{rec}/F_{bar}). EWG 20-02 considered the stocks identified in Annex XIV of the technical measures Regulation (EU) 2019/1241. The technical measures were categorised according to chapter III of the technical measures regulation (EU 2019/1241), articles 16 to 20 and, based on expert opinion, relevant measures have been selected for evaluation.

The choice of an appropriate indicator to assess the impact of the technical measures was discussed at length by EWG 20-02 because the available indicator has the disadvantage of not being able to disentangle the effect of technical measures from other external drivers such as changes in fishing effort, fishing patterns or other management measures.

Population selectivity has been selected as an appropriate measure because it describes the distribution of fishing mortality over the different age-classes of an exploited fish stock. It allows the assessment of the pressure on juveniles and it can track selectivity changes in the fishery. Further, it is robust to recruitment variability and changes in overall fishing pressure. The EWG noted that F-at-age is often estimated with large uncertainty, making the indicator based on very uncertain. Therefore, the results should be interpreted with caution. Further, inferring causation from a correlation (or lack of correlation) without additional information is not recommended. An additional challenge is that the changes in selectivity of a single fleet or metiér will often not be apparent at population scale, and hence changes in selectivity in single fllets may go undetected.

Alternative methods addressing these shortcomings should be discussed and prepared well in advance of similar future evaluations. Additionally, data availability was an issue for (limited) some of species, particularly in the Celtic Sea and SWW. There is, thus, a need to revisit the indicator and the whole process of how to approach the evaluation of technical measures and who is needed for the assessment.

By region, the main findings of EWG 20-02 were:

Baltic Sea

For the Baltic Sea, four stocks were considered: western Baltic cod, eastern Baltic cod, plaice in the Kattegat, Belts and Sound, and Baltic plaice. There have been numerous changes in technical measures that were implemented between 2010 and 2019 - some of them potentially conflicting and/or with varying degrees of enforcement. The mean length of the age classes used for F_{rec} does not relate to MCRS in a consistent way across the four stocks.

The selectivity measures applied to the Baltic trawl fishery aimed mainly at improving the size selectivity of both Baltic cod stocks. In 2010, the codend mesh size (stretched mesh opening) was increased from 110mm to 120mm. During the period 2010 to 2019, only minor gear related changes in technical measures were implemented. Therefore, it is to be expected that the indicator would not change. Spawning closures for Baltic cod stocks were implemented in the late 1990s, but with varying spatial and temporal extent. These are not expected to impact selectivity on fish below MCRS. In 2015, the MCRS changed for both Baltic cod stocks from 38 cm to 35 cm. Together with the introduction of the landing obligation, this change should have reduced the amount of cod catches below MCRS. As this measure merely changes the assignment of catches to under or over MCRS, it is not expected to change the actual catch profiles and the indicator.

Overall, EWG 20-02 did not identify any obvious correlation between changes in the selectivity indicator and specific changes in technical measures for the species investigated.

North Sea

In the North Sea five species were evaluated - cod, haddock, whiting, saithe and plaice. The selectivity indicator shows a gradual decreasing trend over the longer term for cod and saithe pointing at a gradual reduction in the catch of juveniles. With the indicator at low level for both species at the end of the time series EWG 20-02 concluded that the objective to protect juveniles further has been achieved. However, this cannot be attributed to specific technical measures and is more likely to be due to a combination of factors including changes in fishing effort and fishing patterns.

The indicator for North Sea haddock and whiting shows a trend over the the time series. For haddock, the indicator has risen over the last few years and is now at a relatively high level compared to the mean of the time series. Therefore, EWG 20-02 concluded that the objective to reduce the catches of juveniles has not been achieved. For whiting, the indicator is close to an all-time low during the most recent years indicating catches of juvenile whiting have been reduced. As for cod and whiting, there are no clear correlations between the indicator and technical measures introduced over the time series. Each of the four roundfish species show an almost simultaneous increase in the indicator during the last 2 or 3 years. This coincides with the removal of the effort restrictions in the North Sea introduced to protect cod.

For plaice, the indicator is highly variable over the entire time series. The indicator is on average high indicating relative high fishing pressure on juvenile plaice. In the most recent years the indicator has decreased, to around the average level over the time series. EWG 20-02 conclude that catches of juvenile plaice have not been reduced and there is no clear correlation between the indicator and technical measures introduced over the time series.

Overall, EWG 20-02 could not identify clear correlations between changes in the selectivity indicator and and the introduction of specific technical measures for any of the species investigated. As in the Baltic Sea, any positive or negative changes in the indicator are thought to be related to a combination of the changes in fishing effort, fishing patterns and in some cases technical measures.

North Western Waters

In the North Western Waters, the following stocks were considered:

- Cod, haddock, whiting and saithe in the West of Scotland
- Rockall haddock
- Cod, haddock, whiting and plaice in the Irish Sea
- Megrim and plaice in the Celtic Sea

For cod in the area West of Scotland, the indicator shows a gradual deterioration in selectivity from 2011 to 2016. There is no obvious reason for this that can be attributed to technical measures, as during this period no major changes were made. Since 2019, the indicator has shown an improving trend but again there is no clear reason for this that can be associated with the introduction of technical measures.

For whiting, the indicator shows a steady deterioration in selectivity since 2008 with high catches of juvenile whiting. This corresponds to significantly reduced fishing effort and catches in the directed gadoid fisheries for cod, haddock and whiting (with more selective gears) and increased catches and effort in the small mesh, less selective *Nephrops* fishery. In this fishery, unwanted catches of small whiting have continued at high levels for many years without any improvement in gear selectivity. For this stock, it is apparent that the objective in Article 3 is not being met due to the exploitation pattern in the *Nephrops* fishery.

As west of Scotland haddock is assessed as part of the North Sea, it is not possible to conclude whether the objectives in Article 3 have been met. The selectivity indicator is highly variable from year-to year from 2008 onwards. It is unclear whether technical measures have had an impact or not.

For saithe, the indicator shows an improving trend from 2008 onwards. However, given the limited changes to the technical measures directly impacting of saithe, it is unlikely the improvement in selectivity observed is related to gear-based measures and more likely related to changes in fishing effort and fishing patterns.

For Rockall haddock, the selectivity indicator shows an improving trend since 2008. Given the overall trend is positive it would seem the objective of reducing catches of juveniles has been achieved. However, as with other stocks EWG 20-02 cannot link this specifically to changes in technical measures which in the Rockall fishery have been limited over the time series.

For the Irish Sea, haddock, whiting and plaice were evaluated. No data was provided for cod. For Irish Sea haddock, while it is difficult to evaluate the selectivity indicator changes across the time series, the indicator has been low for the age 0 fish since 2010 suggesting that the objective of protecting the juvenile fish has been achieved. There is no clear evidence of a link with changes in technical measures or management over the time series.

The indicator for Irish Sea whiting is highly variable over the time series. Hence, it is not possible to conclude whether the objective of reducing juveniles has been reached, noting that the stock is highly depleted and recruitment has been very low for an extended period. Whiting has only been caught as a bycatch in the *Nephrops* fishery, most of which has been discarded.

For Irish Sea plaice, the level of the indicator shows a positive trend. However, it is possible that the increase in the indicator is due to the substantial increase in the stock, generally strong recruitment and low fishing pressure over the time series. EWG 20-02 cannot indentify qany clear evidence of a link with changes in technical measures or management for these species and suggests the positive trend is linked more to be the decline in the fishery for sole in the Irish Sea, from which plaice was an important bycatch. Most plaice catch in the Irish Sea are as a bycatch from the *Nephrops* fishery.

For Celtic Sea, two stocks - megrim and plaice in 7e - were considered. No data was available for other Celtic Sea stocks.

For megrim, indicator shows a decreasing trend and is at a very low level in 2020 for both age classes, suggesting that selectivity for juveniles has significantly improved over the last 10 years. However, there is no clear evidence to suggest this has been a result of specific technical measures as few new measures have been introduced into the Celtic Sea that would impact megrim. The positive trend is more likely linked to the reduction in fishing effort seen over the last 5-year period.

The indicator for Western Channel plaice shows a decreasing trend and is currently at a very low level, suggesting that selectivity for juveniles has significantly improved over the last 10 years. However, changes to technical measures over the time series have been minimal and therefore the positive trends are more likely to result from changes in fishing effort and fishing practices.

Overall, EWG 20-02 could not detect any clear correlations between changes in the selectivity indicator and the introdiction of specific technical measures for any of the species investigated. For several stocks (e.g. West of Scotland whiting, Rockall haddock and Celtic Sea megrim) there seems to be a correlation between reductions in fishing or changes in fishing patterns and the trends shown by the selectivity indicator.

South Western Waters

For the South Western Waters six stocks were considered covering the geographical areaof ICES zones VIII, IX and X (waters around Azores), and CECAF zones (2) 34.1.1, 34.1.2 and 34.2.0 (waters around Madeira and the Canary Islands). The stocks considered were Northern and Southern hake, three megrim stocks and of the whiting stock in the Bay of Biscay.

The ICES assessment model for hake is a length based model, and uses length-based input data. Due to this absence of F at Age data, no assessment could be made for the hake stocks and only a timeline of changes in technical measures and management measures has been provided.

For megrim and four-spot megrim, the selectivity indicator shows a decreasing trend indicating a reduction in the catch of juveniles. However, the indicator shows the high variability throughout the time series, making it difficult to draw any clear conclusions. No technical measures specifically related to megrim have been introduced over the time series, so the reason for this trend is unclear.

For whiting, no data was available, so no assessment was carried out.

EWG 20-02 has only been able to assess the megrim stocks in South Western Waters for which, there is no clear correlation between technical measures and the trends shown by the indicator. For the other SWW stocks, hake and whiting, data issues prevented any evaluation.

Mediterranean

Most Mediterranean fish stocks are currently assessed using separable models, which assume stable population selectivity. This hinders wider exploration of the temporal development of selectivity in the area. As in other regions, trends in the selectivity indicators may relate to not only gear-based technical measures, but also to tactical changes in fishermen’s behaviour.

For several stocks examined - hake in GSAs 1,5,6,7; red mullet in GSAs 17,18- there is some evidence of an improvement in selectivity (lower values of Frec/Fbar) after 2010. For red mullet, the indicator shows a positive trend during the last few years of the time series, which is worth to monitor. For these two species, the objective to reduce the catch of juveniles seems to have been reached in the target GSAs but a clear link to technical measures could not be established.

Regarding temporal biomass patterns, increases have been observed for red mullet from 2008 onward, in several Med GSAs (Vasilakopoulos et al., 2014; Tserpes et al., 2016; STECF, 2016, Cardinale and Scarcella, 2017). Such increases are in line with recent assessment studies suggesting that several Mediterranean red mullet stocks are in a better situation than other deep-water stocks. It is likely that the implementation of Council Regulation (EC) No 1967/2006, which introduced additional trawling prohibitions in coastal areas, has contributed to this improvement. Notably, both red mullet and striped red mullet the recruitment mainly occurs very close to the coast, at depths ranging 10-50 m.

For two other stocks - striped red mullet in GSA 5; hake in GSAs 9,10,11 - the selectivity indicator does not show any clear trend and no conclusions can be drawn on whether the objective of reducing catch of juveniles has been attained or not. Similarly, for deep-water rose shrimp in GSAs 9,10,11, the indicator shows no clear trend. On these last three species in the investigated areas, EWG 20-02 suggests that the technical measures introduced in 2010 (square-mesh codend or an increase in the minimum diamond-mesh size) does not seem to have a clear and detectable effect. However, for hake and red mullet, the indicators mark a relative minimum of a downtrend in the recent years (e.g., decreasing fishing pressure on juveniles), although the variability of the selectivity indicator makes it difficult to assess this as a consistent effect related to the technical measures.

Regarding the technical measures introduced by the MAP in western Mediterranean by the EU Regulation 1022/2019, EWG 20-02 did not detect any influence of these measures based on the indicator. EWG 20-02 suggests it would be interesting to investigate the effect of the closed areas introduced in 2012, especially in the GSA 17,18 for hake to protect spawning aggregations in the Jabuka pit. This was not possible as the stocks are assessed using separable models resulting in an unchanged Frec/Fbar ratio over the time series

In general. it can be concluded that a limited number of correlations have been detected between technical measures and the indicator but no causal correlation could be formulated for any of the species in any of the areas investigated, mainly because of uncertainty of the potential effects of external drivers.

There is very limited data to reflect historic development in population size and/or bycatch of mammals, seabirds and reptiles. As a result, the evaluation of whether objectives are achieved cannot be directly evaluated. However, EWG 20-02 noted that the effort in static gear in the Baltic Sea has decreased substantially in the later years and hence pressure on seabirds and mammals in this area is expected to have decreased. In the Northeast Atlantic, fishing effort (primarily trawl) has decreased over the past 20 years with an expected associated decrease in the pressure on sensitive species. In the Mediterranean, no decrease in fishing pressure has occurred and as a result, no decrease in bycatch mortality of sensitive species is expected to have occurred.

The areas closed under the 2019 technical measures regulation appears to have been effective in preserving some vulnerable ecosystems located in deep-sea areas. The measures taken are straightforward in that they prohibit the use of bottom contacting gears and some passive gears in these areas. The monitoring through VMS onboard vessels should ensure compliance with these rules. The introduction of new areas to protect has been facilitated by the means of delegated acts (Art 29 in the TMR), based on Joint Recommendations submitted by the Regional Groups of Member States that are assessed by STECF to ascertain that sufficient scientific knowledge proving that an area would deserve protection. Additionally, measures implemented to protect and rebuilt commercial stocks can indirectly reduce the impact on seabeds and protect marine ecosystems as the spatial footprint required to catch quotas is reduced.

Some seabeds are more sensitive than others to some fishing practices such as bottom trawling. Therefore, they are candidate areas for areas requirering further protection. EWG 20-02 noted that the areas where most fishing effort is deployed are not necessarily where the impact of fishing is/will be the largest. Mapping sensitive habitats inform on what areas to protect but not necessarily on areas that require further protection. This is because i) the impact depends on the type of fishing gear used (e.g., gear penetrating deep into the sediments are impacting, and, at the meantime, some of these gears could sweep a relatively smaller area in total per unit of effort or per unit of landed fish), and ii) it is often observed that the fishing is typically patchily distributed which is explained by unsuitable bottom types to trawling, regulatory rules (ban on the coastal strip), or occupation of the space by other uses.

2. Introduction

According to Article 31 of Regulation (EU) 1241/2019[8] on the conservation of fishery resources and protection of marine ecosystems through technical measures, the Commission is required to report, following evaluation by STECF, on the extent to which technical measures both at regional level and at European Union level have contributed to achieving the objectives set out in Article 3 and reaching the targets set out in Article 4 of Regulation (EU) 1241/2019. The first report is due to submitted on the 31 December 2020, with reports every three years thereafter.

To facilitate this, STECF is requested by the Commission to evaluate the performance of technical measures to conserve fishery resources and protect marine ecosystems. STECF should consider the following elements in their evaluation:

- selectivity improvements;
- innovative gears (e.g. pulse trawl);
- catches of marine species below MCRS;
- incidental catches of marine mammals, sharks, reptiles, seabirds and other sensitive species;
- the impact of fishing activities on seabed habitats;
- the optimisation of exploitation patterns to provide protection for juvenile or spawning aggregations of marine resources;
- the minimisation and possible elimination of incidental catches of sensitive species (as defined in Article 6(8) of that Regulation); and
- minimising the environmental impacts of fishing.

Specific attention should be paid to areas where, at regional level, there is evidence that the objectives and targets as set out in Articles 3 and 4 of Regulation (EU) 1241/2019 have not been met.

STECF is also asked to advise on the most appropriate selectivity performance indicators for comparative evaluation of fishing gears according to Article 16 of Regulation (EU) 1241/2019. In preparing its advice, STECF shall inter alia consider the use of the length of optimal selectivity (Lopt) compared to the average length of fish caught. As part of its evaluation, STECF shall calculate historic time-series of the most appropriate indicator identified for each of the commercially exploited stocks where feasible.

Based on the discussions held at PLEN 20-02 with DG MARE and the co-chairs of the EWG, the following were agreed:

Selectivity Indicators

EWG 20-02 will advise on an appropriate indicator of gear selectivity to be used both for tracking long-term changes in fisheries selectivity but also for assessing selectivity characteristics according to Article 16 of the Technical Measures Regulation. It was agreed that the EWG will build on the work on age-based selectivity indicators initiated by STECF EWG 18-15 and further developed by Vasilakopoulos et al. (2020)[9]. The EWG will also consider the length of optimal selectivity (Lopt) building on work by ICES WKLIFE and others.

DG MARE will request ICES to provide F-at age data by stock and by fleet/fishery, in digital format where possible. The stocks concerned are those that are mentioned in Annex XIV of the Technical Measures Regulation. Information on additional species covered under the relevant multiannual plans will also be requested. Depending on the availability of data, analysis of these additional stocks will be undertaken by EWG 20-02. For the Mediterranean F-at age data can be extracted from the Mediterranean stock assessment data held by the JRC and used by the STECF Mediterranean stock assessment EWGs.

Sensitive species

EWG 20-02 will report on the best available estimates of sensitive species (including protected fish species, seabirds, sharks, turtles, cetaceans) disaggregated by species, fishery and Member State in relation to the conservation status of each species.

Based on the discussions at PLEN 20-02, it was agreed that no formal data requests were required for sensitive species. It was identified that publically available data from ICES Working Groups and workshops (WGBYC, WKLIFE) and a variety of other sources (e.g. research projects such as STREAM and PROBYFISH, previous analysis by STECF, FDI data, GFCM etc) would provide the most up-to-date knowledge available, and at the most disaggregated scale possible given the scarcity and the variability of data. STECF PLEN 20-02 emphasised that it will not be possible to provide accurate indicators for all fleets and metiers.

Sensitive habitats

EWG 20-02 will use the data generated by ICES WGFBIT and EMODNET to provide an analysis of the impacts of fishing gears on sensitive habitats. This data is publically available through the GITHUB repository. This includes data for the main sea basins including the Mediterranean.

3. Terms of reference

1. Evaluate the performance of technical measures to conserve fishery resources and protect marine ecosystems according to Article 31 of Regulation (EU) 1241/201.
2. Evaluate the extent to which technical measures both at regional level and at Union level have contributed to achieving the objectives set out in Article 3 of said Regulation and reaching the targets set out in Article 4, including progress that has been made or impact arising from innovative gear.
3. Advise on the most appropriate selectivity performance indicator for comparative evaluation of fishing gears according to Article 16 of Regulation 1241/2019. In preparing its advice, STECF may inter alia consider the use of the length of optimal selectivity Lopt compared to the average length of fish caught. Where possible, EWG 20-02 should calculate time-series of the appropriate selectivity indicator for each of the main commercial fish stocks and areas, considering those included in Anne XIV of the TMR.
4. Assess the progress made or impact of innovative gear and evaluate the use of innovative gears, drawing conclusions about the benefits for, or negative effects on, marine ecosystems, sensitive habitats and selectivity based on the most recent advice from ICES and other relevant scientific organizations.
5. Report on the best available estimates of sensitive species (incl. seabirds, sharks, turtles, cetaceans) disaggregated by species, fishery and Member State in relation to the conservation status of each species with an assessment whether by-catch rates are changing over time and to identify problematic fisheries that may require specific attention.
6. Report on data on impacts of fisheries on habitats and ecosystems that help to identify areas where further efforts are needed to address adverse impacts on the sensitive habitats including vulnerable marine ecosystems (VMEs)

EWG 20-02 should have regard to advice from ICES and GFCM and should draw conclusions about the benefits achieved for, or negative effects on, marine ecosystems, sensitive habitats and selectivity. Specific attention should be paid to areas where, at regional level, there is evidence that the objectives and targets as set out in Articles 3 and 4 of Regulation (EU) 1241/2019 have not been met.

The evaluation shall cover the period from 1 January 2014 and shall cover, to the extent possible, fisheries by EU fishing vessels in all the fishing zones defined in Article 5 of Regulation 1241/2004 (North Sea, Baltic Sea, north western waters, south western waters, the Mediterranean Sea east of 5°36’W, the Black Sea, the NEAFC regulatory area and Union waters in the Indian Ocean and the West Atlantic.

4. TOR 1 to 4

General introduction

Introduction of population selectivity indicators

Population selectivity describes the differential vulnerability to fishing of the demographic components of an exploited fish population, as a result of the gear used (e.g., choice of mesh size) and availability (e.g., choice of fishing timing and location) (Millar & Fryer, 1999). In age-structured stock assessments, population selectivity is usually expressed as the distribution of fishing mortality over the different age-classes of an exploited fish stock (Sampson & Scott 2012). Population selectivity is important because it affects both Maximum Sustainable Yield (BMSY) and FMSY, as well as stock resilience to overfishing (Scott & Sampson, 2011).

STECF EWG 18-15 concluded that population independent metrics such as Catch and CPUE at age (which may be improved through weighting by population numbers) allow a direct comparison between fleets. It is, however, not possible to disentangle whether inter-annual changes in catch or CPUE at age are a consequence of changes in population (e.g. weak or strong recruitment) or due to changes in technical or tactical strategies of the fleet, including improvements in selectivity. Population independent metrics (i.e. using partial fishing mortality) potentially provide a more robust means of comparing changes in exploitation pattern both between and within fleets over time as they are less susceptible to changes in the underlying population and could therefore be more useful to assess the efficacy of technical and/or tactical measures aimed at avoiding certain age groups (e.g. juveniles). Based on these observations, EWG 18-15 undertook a simulation study and more detailed empirical analysis on a limited number of catch-based and F based indicators.These indicators were further reported on by Vasilakopoulos et al. 2020, who tested population selectivity indicators (“selectivity indicator” hereafter) to provide managers with an additional metric describing whether a stock has achieved desirable stock status through improvements in selectivity. Such a selectivity metric could inform managers on the uptake by fleets and effects on stocks of various technical measures introduced to improve selectivity (STECF, 2018; Vasilakopoulos et al. 2020) demonstrated the ratio of F of the first recruited age class (Frec) to Fbar (Frec/Fbar is an informative selectivity metric for fisheries management and advice. It was shown to be able to track selectivity changes happening in the fishery and was robust to both recruitment variability and changes in overall fishing pressure.

Figure 1 shows the pressure on the different age classes for the western Baltic cod stocks in the form of F-at-Age. The selectivity indicator is calculated as the pressure on the recruits (F_{rec}) divided by the pressure on the adult age classes (F_{bar}). If F_{rec} consists of more age classes, the most suitable age class should be chosen.

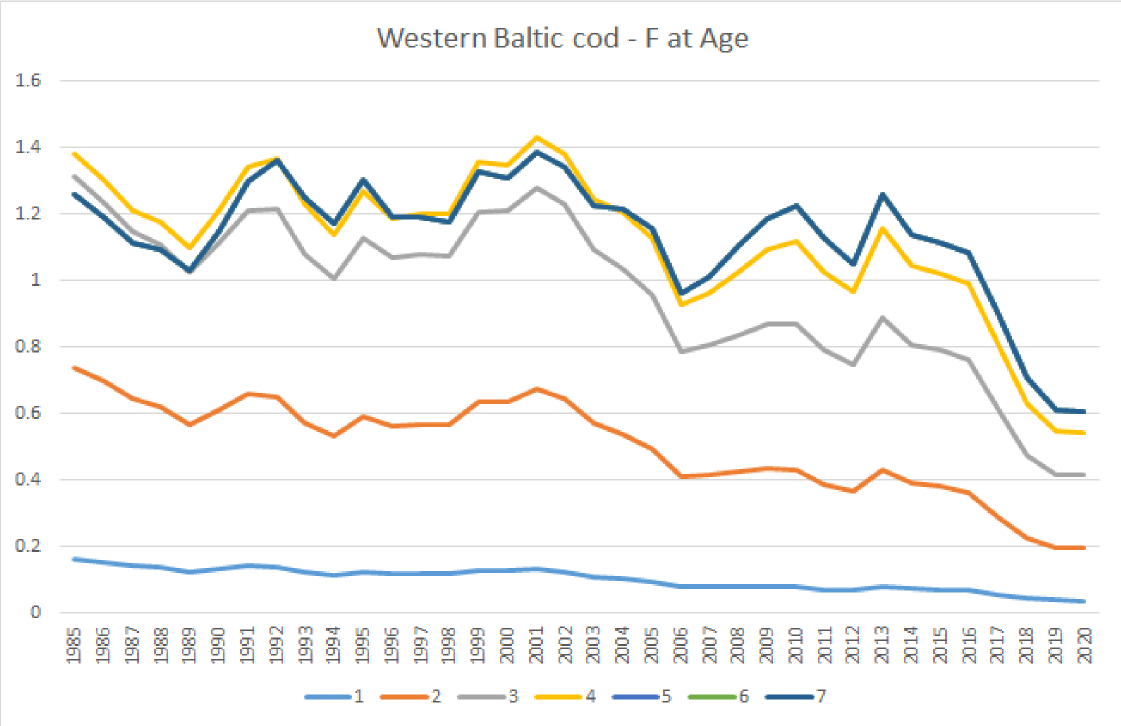

Figure 1: Example for time series of F at age-matrix as basis for calculated selectivity indicator F_{rec}/ F_{bar}. F at age for the western Baltic Sea cod stock (ICES areas 22-24).

Caveats of the approach

STECF has been requested by the Commission to evaluate the performance of technical measures to conserve fishery resources and protect marine ecosystems.

This section aims to use the selectivity indicator F_{rec}/ F_{bar} (the ratio of F of the first recruited age-class to F_{bar} (F of the fully exploited age-classes); Vasilakopoulos et. al., 2020) to investigate how fishing selectivity has evolved over time and try to relate fluctuations in the time series to changes in the technical measures.

Carrying out such a task comes with multiple caveats and may lead to a post hoc fallacy (since event B (a change in selectivity) followed event A (a change in the technical measures), event B was caused by event A). Doing so, may lead to wrongly identifying the underlying causes for the change, or alternatively, wrongly saying that the technical measure was ineffective. Furthermore, the introduction of technical measures does not ensure that the fishing industry has abided by them. For example, there are examples throughout Europe where selectivity improvements made to fishing gears have been negated once introduced into legislation (e.g. Krag et. al., 2016; Suuronen and Sarda. 2007). The introduction of the landing obligation may also have changed the willingness of the fishery to contribute to catch sampling, which may directly influence the quality of the estimate of Frec. Additionally, without taking into consideration all changes to the system (including fisheries management, socio-economic framework), the underlying cause for the changes observed may be misidentified. We also note that F-at-age is usually estimated with large uncertainty, making the indicator based on it also uncertain. Therefore, the following section should be interpreted with caution. EWG 20-02 does, however, consider the indicator selected for this evaluation as the better choice of available indicators.

Confidence in input data

F at Age data

F at age is an output of stock assessments based on catch data. Typically, very low numbers of individuals in the younger age classes are landed. Therefore, these age classes typically rely on data collected as part of discard sampling programmes. These programmes typically have very low sampling intensities and thus large uncertainties in the estimates. Since 2015, the collection of these data has been further complicated by the fact that discarding under the landing obligation is illegal, which increases the risk of an observer effect on the discard patterns in sampled trips and can also lead to increased difficulties for observers to be allowed on board fishing vessels.

Type of assessment models

There is a great variety of age-structured stock assessment models currently used for assessing European fish stocks. Notably, there are some stock assessment models (e.g. a4a, ASAP) where fishing mortality is considered separable, (i.e. the product of an age factor and a year factor), and population selectivity remains unchanged. Separable stock assessment models are often preferred in cases of “noisy” input data, short-time series and to address model convergence issues. Separable models result in F_{rec}/ F_{bar} being either virtually unchanged throughout the whole time-series (as is the case for many Mediterranean stocks), or unchanged over specific ‘year-blocks’ (as is the case for some Irish Sea stocks). In the former case, no inferences can be made for the temporal development of selectivity, while in the latter, selectivity exhibits step-changes rather than a continuous temporal development.

Confidence limits

The data provided to the EWG from ICES were provided without confidence intervals and therefore it has not been possible to provide confidence intervals around the indicators. This may affect the estimation of trends as the uncertainty is generally greater in the final years of the timeseries. This is not accounted for in the present analyses.

Technical measures

In this analysis, EWG 20-02 has considered the species/stocks identified in Annex XIV of the technical measures regulation (EU 2019/1241). The technical measures have been categorised according to chapter III of the technical measures regulation (EU 2019/1241), articles 16 to 20. The technical measures comprise of the following categories:

a) Species and size selectivity of fishing gear (Article 16)

b) Closed or restricted areas to protect juveniles and spawning aggregations (Article 17)

c) Minimum conservation reference sizes (Article 18)

d) Real-time closures and moving-on provisions (Article 19)

e) Innovative fishing gear (Article 20)

Additional measures also included are - if appropriate - the introduction of the Landing obligation, regional technical measures, nature conservation measures, regional measures under temporary discard plans, pilot projects on full documentation of catches and discards.

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Summary table

Table 1: Summary of the evaluation results, all areas all species considered

Region	Stock	Trends (2010-2019)	Comments
NWW	West of Scotland Cod 6a	Between 1980-2003, the indicator shows poor selectivity. The indicator shows an improvement in the period 2002-2011. After 2011 the indicator shows a gradual deterioration up to 2016. Since 2019 there has been a marked improvement of the indicator pointing at a recent reduction in pressure on juvenile cod.	No clear linkage with changes in technical measures. Positive trend may reflect changes in fishing patterns and the low level of the cod stock over a protracted period.
NWW	West of Scotland Whiting 6a	The shape of the selectivity curve in this stock was asymptotic, with the highest selection occurring at age 4–6, apart from the last five years of the time series when selection peaked at age 1. From 1995 onwards, a slow deteriorating trend in selectivity (i.e., higher targeting of juveniles) was captured by the indicator, which was further accelerated from the early 2000s onwards, when the SSB was depleted. At present the indicator is at its maximum value pointing at a relative high pressure on juvenile whiting.	The negative trend corresponds to significantly reduced fishing effort and catches in the gadoid fisheries for whiting (with more selective gears) and increase catches and effort in the small mesh, less selective Nephrops fishery as evidence by the partial F's.
NWW/North Sea	West of Scotland and North Sea Haddock	West of Scotland haddock is considered a small component part of the North Sea haddock and therefore it is not possible to conclude on the trends in selectivity solely for the West of Scotland component of the stock. The stock has a history of strong recruitment pulses and a big Fbar reduction after 2000. The indicator shows a gradual deterioration in selectivity up to about 2002 and then a gradual improvement up to about 2015. Recruitment in the stock has been low in this period. From 2015 onwards, the trend shows a decline in selectivity.	No clear linkage
NWW/North Sea	West of Scotland and North Sea Saithe	As with West of Scotland haddock, saithe in area 6 is a component of the wider North Sea saithe stock. Over the entire time series, the indicator trend since 1980 has shown a gradual improvement in selectivity and in the West of Scotland, this corresponds to a period of quite stable catches and relatively stable levels of fishing effort in the trawl fishery, which accounts for most saithe catches.	The improving trend in selectivity in this case is unlikely to have any linkage to changes in technical measures.
NWW	Rockall Haddock	The indicator starts around 0.3 in the early '90s, reaches a maximum in 1998 after which there is an improvement in pressure on juveniles. This is followed by a deterioration between 2005-2009. From	Generally, the indicator shows selectivity has improved and stabilized. The two spikes 2013 and 2016 can possibly linked to spikes in the partial F's for bottom trawls.

		2009 to 2011 the indicator shows an improvement in selectivity which corresponds to a period of very low recruitment in the fishery and the decline of the Russian fishery for juvenile haddock. From 2011, the selectivity pattern has been relatively stable apart from two peaks in 2013 and again in 2016.	
NWW	Irish Sea Cod	No data	No data
NWW	Irish Sea Haddock	No clear trend	While it is difficult to evaluate the selectivity indicator changes across the time series, since 2010, the indicator has been low for the age 0 fish suggesting that the objective of protecting the juvenile fish has been achieved. No evidence of a link with changes in technical measures or management
NWW	Irish Sea Whiting	The indicator appears to have two different periods with a sudden step change in 1994. It should be noted that both periods have relatively low values.	There is no management measure apparent that could explain this!
NWW	Irish Sea Plaice	The indicator has been steadily increasing since 1980, and this has accelerated since around 2005, and possibly again from 2015. This means the index is getting worse, but no real “events” or breaks can be seen in the index plot. Recruitment has apparently been strong and consistent for many years, with a recent decrease.	This indicator trajectory cannot be linked to any particular management measure. The main feature of this stock is that it was a bycatch in the beam trawl fishery targeting sole. Since the collapse of the sole fishery, the effort on plaice has declined.
NWW	Celtic Sea Megrim	The indicator pattern at age 1 shows a steady increase from 1995, peaking in 2011, with a sharp decline to the present. The indicator level is still higher than in the 1980s , but in any case is very low at less than 0.15. The key break year is 2010-11.	The indicator suggests that selectivity for young fish has improved over the last 10 years. No links with technical measures as there have been only minimal changes
NWW	Western Channel Plaice	The pattern in the indicator shows a noisy, but steady slow trend rising from 0.2-0.3 in the 1980s, to perhaps 0.3-0.4 in 2011. This was followed by a sharp decline to under 0.1, though it has risen again from 2016 to now.	The indicator, suggests that selectivity for young fish has significantly improved over the last 10 years. No clear linkage with technical measures but possible linkage with the Sole and plaice plan
SWW	Hake in subareas 4, 6, and 7, and in divisions 3.a, 8.a–b, and 8.d, northern stock	---	---
SWW	Hake in divisions 8.c and 9.a, Southern stock	---	---
SWW	Megrim in divisions 7.b–k, 8.a–b, and 8.d	The trend of selectivity indicator shows a global improvement of juveniles protection but the high variability along the years indicates a relatively instable situation.	There are no technical measures directly focused on this stock so the reason of this positive trend is unclear.
SWW	Four-spot	The trend of selectivity indicator shows a	There are no technical measures

	megrim in divisions 8.c and 9.a	global improvement of juveniles protection but the high variability along the years indicates a relatively instable situation.	directly focused on this stock so the reason of this positive trend is unclear.
SWW	Megrim in divisions 8.c and 9.a	The trend of selectivity indicator shows a global improvement of juveniles protection but the high variability along the years indicates a relatively instable situation.	There are no technical measures directly focused on this stock so the reason of this positive trend is unclear.
SWW	Whiting in Subarea 8 and Division 9.a	No data	
Baltic	Cod SD22-24 Western Baltic	The indicator shows a decreasing trend since the beginning of the time series in 1985 pointing at a decreasing fishing pressure on juveniles. The last decade shows a stabilised to decreasing trend in the indicator.	Numerous changes in technical measures were implemented between 2010 and 2019. It is not possible to infer causal relationships between changes in the selectivity indicator and any specific changes in technical measures.
Baltic	Cod SD24-32 Eastern Baltic	The indicator has been stable over the first part of the time-series, whereas a decreasing trend, with fluctuations, can be seen over the last two and a half decades. When looking at the last 10 years, the indicator behaves the same, with large fluctuations and slight decreasing trends.	Numerous changes in technical measures were implemented between 2010 and 2019. It is not possible to infer causal relationships between changes in the selectivity indicator and any specific changes in technical measures.
Baltic	Plaice SD21-23	No trend. Considering the extremely small magnitude of the fluctuations, we can say that the indicator remained stable over the whole time series.	Numerous changes in technical measures were implemented between 2010 and 2019. It is not possible to infer causal relationships between the absence of changes in the selectivity indicator and changes in technical measures.
Baltic	Plaice 24-32 Western Baltic	Overall, since the beginning of the time series, the indicator has more than halved, which indicates an improvement in selectivity and juvenile protection. Looking at the last 10 years, the indicator drops in 2013, goes up again and drops again from 2016 onwards.	Numerous changes in technical measures were implemented between 2010 and 2019. It is not possible to infer causal relationships between changes in the selectivity indicator and any specific changes in technical measures.
North Sea	North Sea cod	The indicator starts reasonably low at the beginning of the time series. It then rises quite steeply to a maximum halfway the 1970's. From 1980 onwards the indicator shows a gradual improvement and drops below its initial value of 0.2 from the year 2000 onwards. The evolution of the indicator points at a gradual improvement of the selectivity for the young fish after 1980 with a slight deterioration since 2016.	EWG 20-02 cannot identify whether this is related to changes in technical measures or reflects changes in fishing patterns.
North Sea	North Sea haddock	The indicator starts at a value around 0.1 in 1970, increases to a maximum around the year 2000 and then decreases, with high variability, to 0.15 at the end of the series. The indicator reached an absolute minimum in 2015 but increases over the last 4 years.	The variability of the indicator makes it difficult to assess whether this as a consistent effect. There is no clear linkage to technical measures. There is no definitive explanation of the deterioration in selectivity after 2015 and it is likely due to changes in fishing patterns.

North Sea	North Sea saithe	The indicator starts at 0.75 at the end of the 1960's. It then rises to a max of 1.3 halfway the 1970's to start its gradual downward slope until present. The indicator suggests a trend of improving selectivity with less fishing pressure on juvenile saithe and an improved exploitation pattern.	EWG 20-02 cannot identify whether this is related to changes in technical measures or reflects changes in fishing patterns.
North Sea	North Sea whiting	The variability of the indicator makes it difficult to assess whether there is a consistent effect.	There seems to be some correlation between the indicator and the technical measures although this is not clear cut and the improvements are likely to be due to a combination of factors.
North Sea	North Sea plaice	The variability of the indicator makes it difficult to assess whether there is a consistent effect.	There seems to be some correlation between the indicator and the technical measures although a causal correlation cannot be proven.
Mediterranean	hake in GSAs 1,5,6,7	The indicator decreases below its initial values of around 0.35 from the years 2008-2009 onwards.	Some evidence of an improvement in selectivity (lower values of Frec/Fbar) after 2010, when more selective codend mesh sizes were introduced
Mediterranean	Red mullet in GSAs 17,18	The indicator decreases below its initial values of around 0.6 from the years 2008-2009 onwards. There is a remarkable increase in the indicator during the last few years of the time series, which is worth to monitor.	Some evidence of an improvement in selectivity (lower values of Frec/Fbar) after 2010, when more selective codend mesh sizes were introduced
Mediterranean	Striped red mullet in GSA 5	The fluctuations of the indicator did not exhibit any clear overall trend	The technical measure introduced in 2010 (square-mesh codend or an increase in the minimum diamond-mesh size) does not seem to have a clear and detectable effect.
Mediterranean	Hake in GSAs 9,10,11	The fluctuations of the indicator did not exhibit any clear overall trend	The technical measure introduced in 2010 (square-mesh codend or an increase in the minimum diamond-mesh size) does not seem to have a clear and detectable effect.
Mediterranean	Deep-water rose shrimp in GSAs 9,10,11	The time-series started in 2009 (Figure 5), so the effect from the 2010 regulation should be examined cautiously.	The technical measure introduced in 2010 (square-mesh codend or an increase in the minimum diamond-mesh size) does not seem to have a clear and detectable effect.

Baltic Sea

This study focuses on four Baltic stocks: Western Baltic cod, Eastern Baltic cod, Plaice SD21-23, Plaice SD24-32. The main relevant changes in technical measures are listed in

2.

Table 2: Changes of technical measures, applied to Baltic Sea fisheries – selection of relevant measures for the period 2010 to 2019

Sea basin	Technical measure	Month	Year	Measure	Species of interest	EU reg no
Baltic Sea	Species and size selectivity	Jan	2010	Increase codend mesh size from 110 mm to 120 mm	Cod	1226/2009
Baltic Sea	Species and size selectivity	Feb	2018	Introduction of Swedish T90 codend (Optional)	Cod	47/2018
Baltic Sea	Species and size selectivity	Jun	2019	Removal of Swedish T90 codend	Cod	
Baltic Sea	Species and size selectivity	Jun	2019	Removal of technical specifications for T90 and Bacoma codends	Cod	
Baltic Sea	Species and size selectivity	Jun	2019	(re)introduction of 90 mm codend when targeting plaice	Plaice	
Baltic Sea	Minimum conservation reference sizes	Jan	2015	Lowered from 38 cm to 35 cm	Cod	1396/2014
Baltic Sea	Closed or restricted areas		2010-2015	Eastern Baltic - Seasonal closure 1st July-31st Aug (SDs 25-28)	Cod	1226/2009, 1124/2010, 0240/2011, 1088/2012, 0286/2013, 1221/2014
Baltic Sea	Closed or restricted areas		2016-2018	Eastern Baltic - Area closure 1st May-31st Oct	Cod	2187/2005 & 1098/2007
Baltic Sea	Closed or restricted areas		2019	Eastern Baltic - Seasonal closure 1st July-31st Aug (SDs 25-26)	Cod	2187/2005 & 1098/2007
Baltic Sea	Closed or restricted areas		2010-2015	Western Baltic - Seasonal closure 1st-30th Apr (SDs 22-24)	Cod	1226/2009, 1124/2010, 0240/2011, 1088/2012, 0286/2013, 1221/2014
Baltic Sea	Closed or restricted areas		2016	Western Baltic - Seasonal closure 15th Feb 31st Mar (SDs 22-24)	Cod	2187/2005 & 1098/2007
Baltic Sea	Closed or restricted areas		2017-2018	Western Baltic - Seasonal closure 1st Feb 31st Mar (SDs 22-24)	Cod	2187/2005 & 1098/2007
Baltic Sea	Closed or restricted areas		2019	Western Baltic - No seasonal closure	Cod	2187/2005 & 1098/2007
Baltic Sea	Closed or restricted areas		2020	Western Baltic - Seasonal closure 1st Feb 31st Mar (SDs 22-23)	Cod	2187/2005 & 1098/2007
Baltic Sea	Closed or restricted areas		2020	Western Baltic - Seasonal closure 1st Jun 31st Jul (SD 24)	Cod	2187/2005 & 1098/2007
Baltic Sea	Landing Obligation	Jan	2015	Landing obligation introduced	Cod	1396/2014
Baltic Sea	Landing Obligation	Jan	2017	Landing obligation introduced	Plaice	1396/2014
Baltic Sea	Landing Obligation	July	2019	Emergency measures - forcing discarding (SDs 24-26)	Cod	1248/2019

The ages classes used for the indicator F_{rec}/ F_{bar} for the various stocks are in Table 3. The choice of age classes was based on the following argumentation: the age-class ranges for F_{bar} were fixed to the ones used for the respective stocks by WGBFAS; for F_{rec} the age classes just below that were chosen. For three of the stocks two indicators, each using a different age class for F_{rec}, were explored. For Ple.27.24-32 we explored only one indicator based on age class 1 for F_{rec} as age class 2 was included in F_{bar}.

As can be seen in Table 4, the mean length of the age classes used for F_{rec} does not relate to MCRS in a consistent way across the four stocks. In some cases the indicator mainly refers to fishing pressure on fish below MCRS whereas in other cases it mainly refers to fishing pressure on fish at or above MCRS. This should be taken into account when interpreting the development of the indicators over time.

Table 3: Baltic stocks considered in the following section, the age class/es used for F_{rec} and F_{bar}.

Stock	**F_{rec} age classes**	**F_{bar} age classes**
Cod.27.22-24	1 & 2	3-5
Cod.27.24-32	2 & 3	4-6
Ple.27.21-23	1 & 2	3-5
Ple.27.24-32	1	2-5

Table 4: Stocks considered in the following section, their mean lengths at age (+ standard deviations) for the ages used in the indicators (and some other ages; based on German data from sampling program of commercial vessels from 2015 to 2019) and their minimum conservation reference size (MCRS).

stock	Mean length@age1	Mean length@age2	Mean length@age3	Mean length@age4	current MCRS
Cod.27.22-24	29.2 (±8.1) cm	40.8 (±7.4) cm	49.9 (±8.1) cm	60.5 (±9.5) cm	35 cm
Cod.27.24-32	27.4 (±2.7) cm	36.0 (±5.9) cm	40.1 (±6.0) cm	40.7 (±5.7) cm	35 cm
Ple.27.21-23	20.7 (±3.4) cm	24.2 (±3.8) cm	27.6 (±3.9) cm	30.6 (±3.9) cm	25 cm
Ple.27.24-32	20.0 (±2.8) cm	23.9 (±2.9) cm	26.9 (±3.2) cm	29.8 (±3.2) cm	25 cm

Western Baltic cod

General stock trends

The following stock summary (Fig. 2) is taken from ICES advice (ICES 2020a).

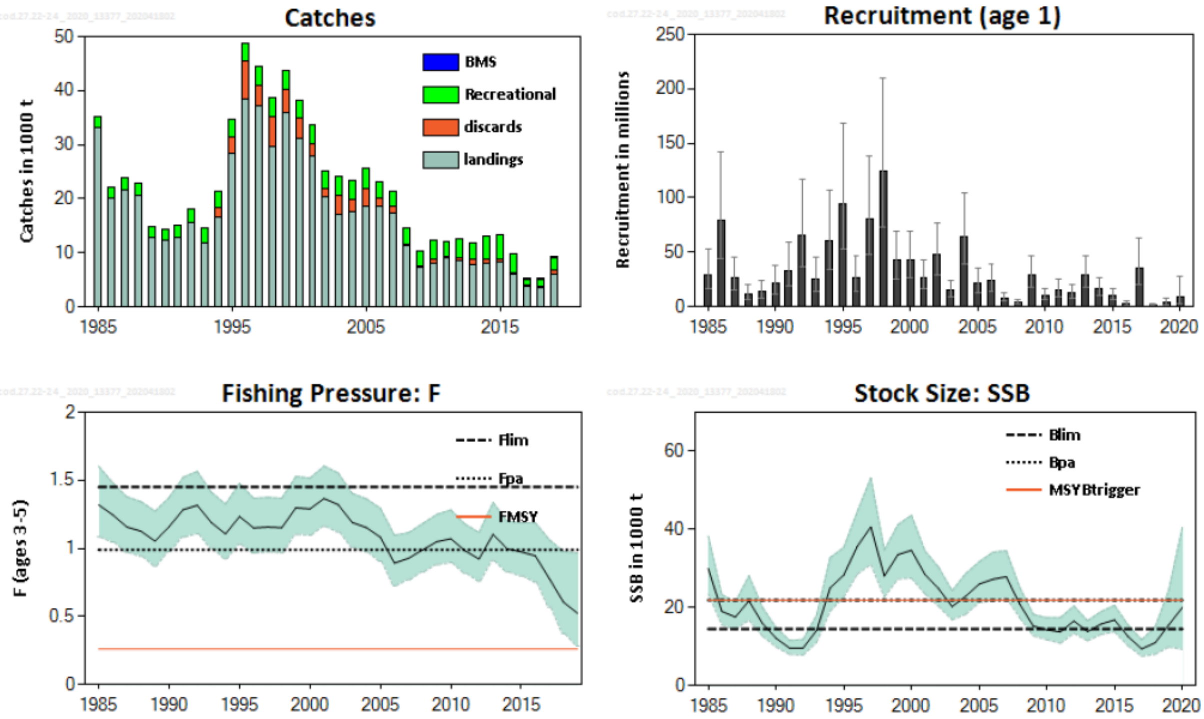

Figure 2: Cod in subdivision 22-24, western Baltic cod stock. Summary of the stock assessment. Recruitment, F and SSB show confidence intervals (95%) in the plot. BMS landings (fish below the minimum conservation reference size [MCRS]) have been included since 2017. Figure taken from ICES 2020a.

Fishing mortality (F) has decreased since 2013 but is above Fmsy, while being below Flim and recently also below Fpa. In the past decade, spawning-stock biomass (SSB) has been fluctuating around Blim and below MSYBtrigger and Bpa; SSB is currently estimated above Blim. Recruitment has been generally low since 2005 and very low in the last three years.

The EU landing obligation for cod was implemented from 1 January 2015. Landings of fish below the minimum conservation reference size (MCRS, 35 cm) are very low in the management area (24 t below minimum size [BMS] reported in 2018). Discarding still takes place despite the fact that the landing obligation has been in place since 2015. The estimated amount of discards is 157 tonnes in 2018 (approximately 4.2%), based on observer data. This is not in accordance with the current regulations (ICES, 2020b).

Quality of assessment

According to ICES (2020b), the quality of this assessment has in recent years become worse. The uncertainty on the catch matrix is relatively high in this assessment. For several years, the model seems to consistently overestimate the catches in the last year; however, in this year's assessment the model underestimated the catch by 42%. This seems to be caused by conflicting information from the surveys and the catch matrix.

Mixing of the eastern and western Baltic cod stocks is a major issue in SD 24. The stock mixing within SD 24 is variable spatially and possibly between seasons and age-groups of cod. This introduces uncertainty to the stock separation keys presently applied in the assessment. Also, for some years in the time series the stock separation keys are based on extrapolations from other years. Further, the preparation of assessment input data to separate between western and eastern Baltic stock involves a number of additional assumptions, which introduce uncertainty to the assessment. However, separating the western Baltic cod (SD 22–23 + the component of western Baltic cod in SD 24) within the management area SD 22–24 after WKBALTCOD (2015) removed several sources of uncertainty characterizing the previous years´ assessments (e.g. age reading issues, higher discards in SD 24).

In conclusion, the uncertainty of the assessment implies that the estimates of F-at-age, used for the indicators, are also quite uncertain.

Selectivity indicator

We looked at two versions of the selectivity indicator F_{rec}/F_{bar}, using age classes 1 or 2 for F_{rec} and age classes 3-5 for F_{bar}. The corresponding length-at-age are given in Table 4, along with the MCRS.

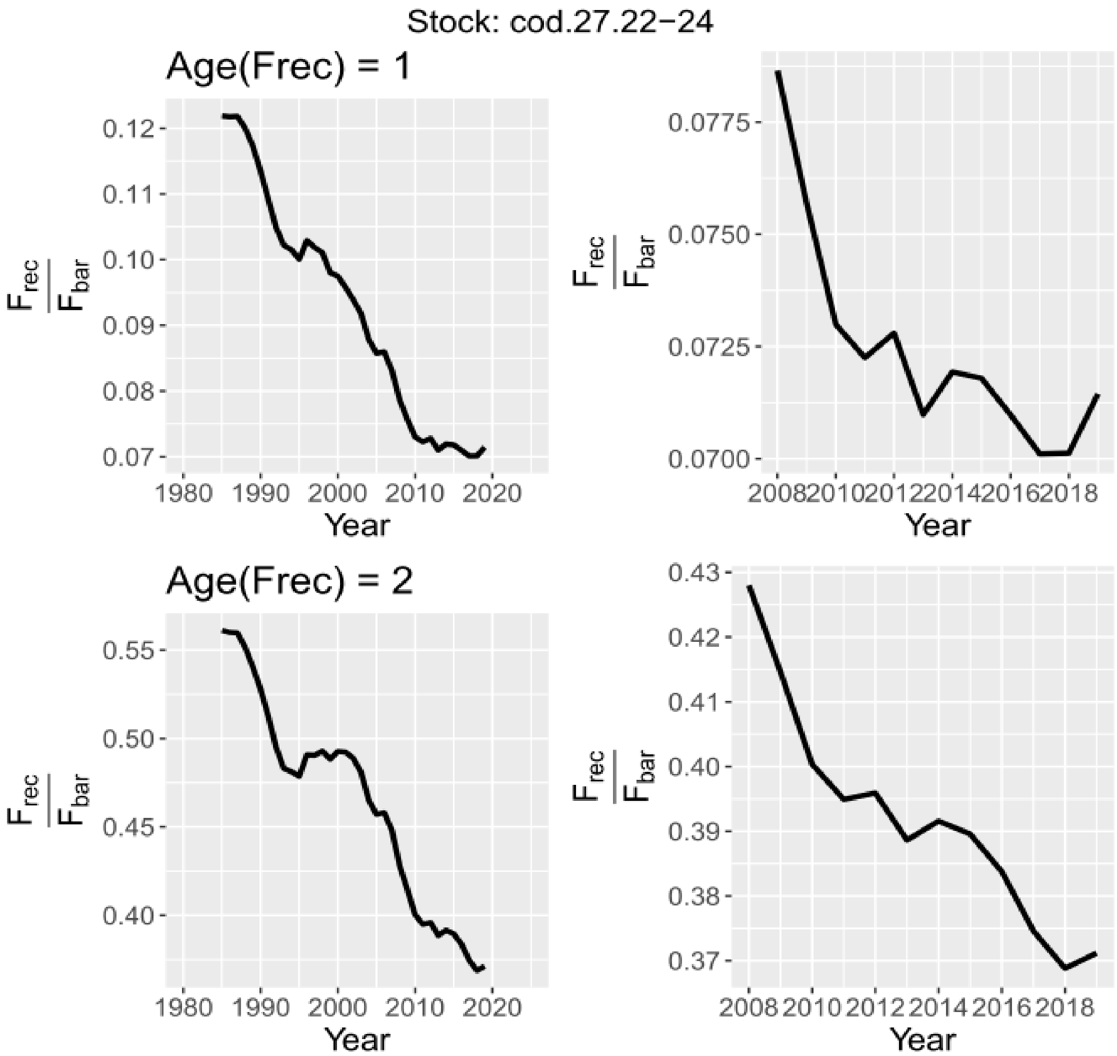

Figure 3: Western Baltic cod stock. Time series of Selectivity indicator F_{rec}/F_{bar}. Left: full time series; Right: reduced time series.

Both indicators show a decreasing trend (i.e. a reduction in F on the smaller age classes (F_{rec}) in relation to F_{bar}) since the beginning of the time series in 1985 (Fig. 3). The indicator with F_{rec} Age class = 1 has more or less stabilized in the last 10 years, whereas the one with F_{rec} Age class = 2 continued to decrease. When looking at the period since 2010, slight fluctuations occurred, which may have been random noise, especially taking into account the uncertainty of the underlying F-estimate (**Error! Reference source not found.**2).

The relevant/major technical measures introduced since 2010 for the cod fishery in the Baltic Sea are given in

5. The technical measures that have changed over the last 10 years comprise of the following categories:

a) Species and size selectivity of fishing gear (EU 2019/1241 Article 16)

b) Closed or restricted areas to protect juveniles and spawning aggregations (EU 2019/1241 Article 17)

c) Changes in MCRS (EU 2014/1396)

d) Introduction of Landing obligation (EU 2014/1396)

a) The selectivity measures, applied especially to the Baltic mixed trawl fishery aimed mainly at improving the size selectivity of both Baltic cod stocks. In 2010, there was a significant change in selectivity in the fishery, when the codend mesh size (stretched mesh opening) was increased from 110mm to 120mm. During the period 2010 to 2019, only minor gear related changes in technical measures with little influence on the size selectivity of cod were implemented (introduction of Swedish T90 codend (optional)). Therefore, it cannot be expected that the changes could have caused substantial changes in the indicator chosen. Apart from the gear related technical measures, there are anecdotal reports about changes in gear selectivity in the fishery to circumvent the significant catch loss caused by using a larger mesh when the abundance of large fish decreased in the mid 2010s.

b) Spawning closures for Baltic cod stocks were already implemented since the late 1990s, but with varying spatial and temporal extent. For the years between 2010 and 2015, a spawning closure was implemented in ICES SD22-24 during April. After a revision of the timing of spawning, the spawning closure was moved to earlier in the year and its duration was expanded (see

5). The spawning closure was not implemented in 2019. Additionally, several exemptions were implemented for parts of the fleet and/or parts of the area in some years.

As the main potential effect of a spawning closure is aimed to be a better recruitment of the stock, the effect on the selectivity indicator is assumed to be lower. Nevertheless, the separation of small fish and spawning fish during the spawning season might result in more clean catches of larger fish on spawning grounds in years when the fishery can target spawning aggregations, resulting in a reduction of the selectivity indicator. The indicator does not show such a trend in 2019, when the spawning closure was not in place - also keeping in mind that the fluctuations over the past 10 years are very low anyhow.

c) In 2015, the MCRS changed for both Baltic cod stocks from 38 cm to 35 cm. Together with the introduction of the landing obligation (d), this change should have reduced the amount of cod catches below MLS/MCRS and hence discards (before 2015) or below MCRS-catches (after 2015). As this measure merely changes the assignment of catches to under or over MLS/MCRS, it is not expected to change the actual catch profiles and thus not affect the chosen indicator.

d) Also in 2015, the landing obligation was introduced for Baltic cod stocks. To make the landing obligation an effective measure to improve the cod stocks in the Baltic, sufficient enforcement is required. The introduction of the landing obligation also changed the willingness of the fishery to contribute to sufficient catch sampling, directly influencing the quality of the estimate of F_{rec}.

In summary, numerous changes in technical measures were implemented between 2010 and 2019 - some of them potentially conflicting and/or not sufficiently enforced. Therefore - and given the uncertainties in the underlying F-estimates - it is not possible to infer causal relationships between changes in the selectivity indicator and any specific changes in technical measures.

Eastern Baltic cod

General stock trends

The following stock summary is taken from ICES advice (ICES 2020c).

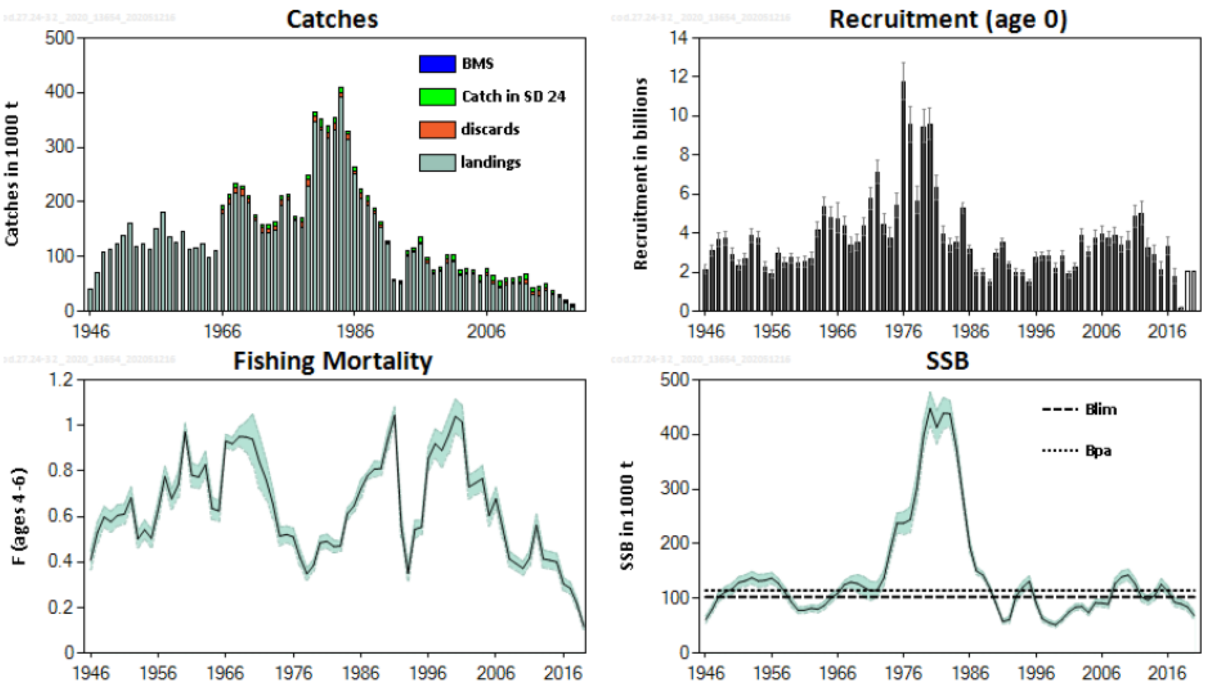

Figure 4: Cod in subdivision 24-32, eastern Baltic cod stock. Summary of the stock assessment. Recruitment, F and SSB show confidence intervals (95%) in the plot. BMS landings (fish below the minimum conservation reference size [MCRS]) have been included since 2017. Figure taken from ICES 2020c.

The spawning stock biomass (SSB) has been declining since 2015 and is estimated to be below Blim. Fishing mortality (F) has declined since 2012. Recruitment (R) has been declining since 2012, and the recruitment in 2017 is estimated to be the lowest in the time series.

Discarding still takes place despite the fact that the landing obligation has been in place since 2015. Landings of fish below the minimum conservation reference size (MCRS; 35 cm) are very low (108 t reported in 2018), compared to the discards (3103 tonnes in 2018) in the management area of SD 25–32. The estimated discard amount in 2018 (approximately 16% of the total catch) was based on observer data, but this is considered to be an underestimate. The available information from the fisheries and observers suggests that modifications to the selectivity properties of the gear takes place, leading to a higher proportion of smaller fish being caught (ICES, 2020).

Quality of the assessment

According to ICES (2020b), survey coverage in SD 26 has been relatively poor in later years, which could affect the CPUE estimates for these years.

It is recognized that age readings for the Eastern Baltic cod are uncertain, especially for later years, while age imprecision is not explicitly accounted for in the stock assessment model. Age length keys up to the present are applied to estimate the yearly values and thus the trend in Von Bertalanffy growth parameters, which are thereafter used to derive catch-at-age from catch-at-length information.

In conclusion, the uncertainty of the assessment implies that the estimates of F-at-age, used for the indicators, are also quite uncertain.

Selectivity indicator

We looked at two versions of the selectivity indicator F_{rec}/F_{bar}, using age classes 2 or 3 for F_{rec} and age classes 4-6 for F_{bar}. The corresponding length-at-age are given in Table 4, along with the MCRS.

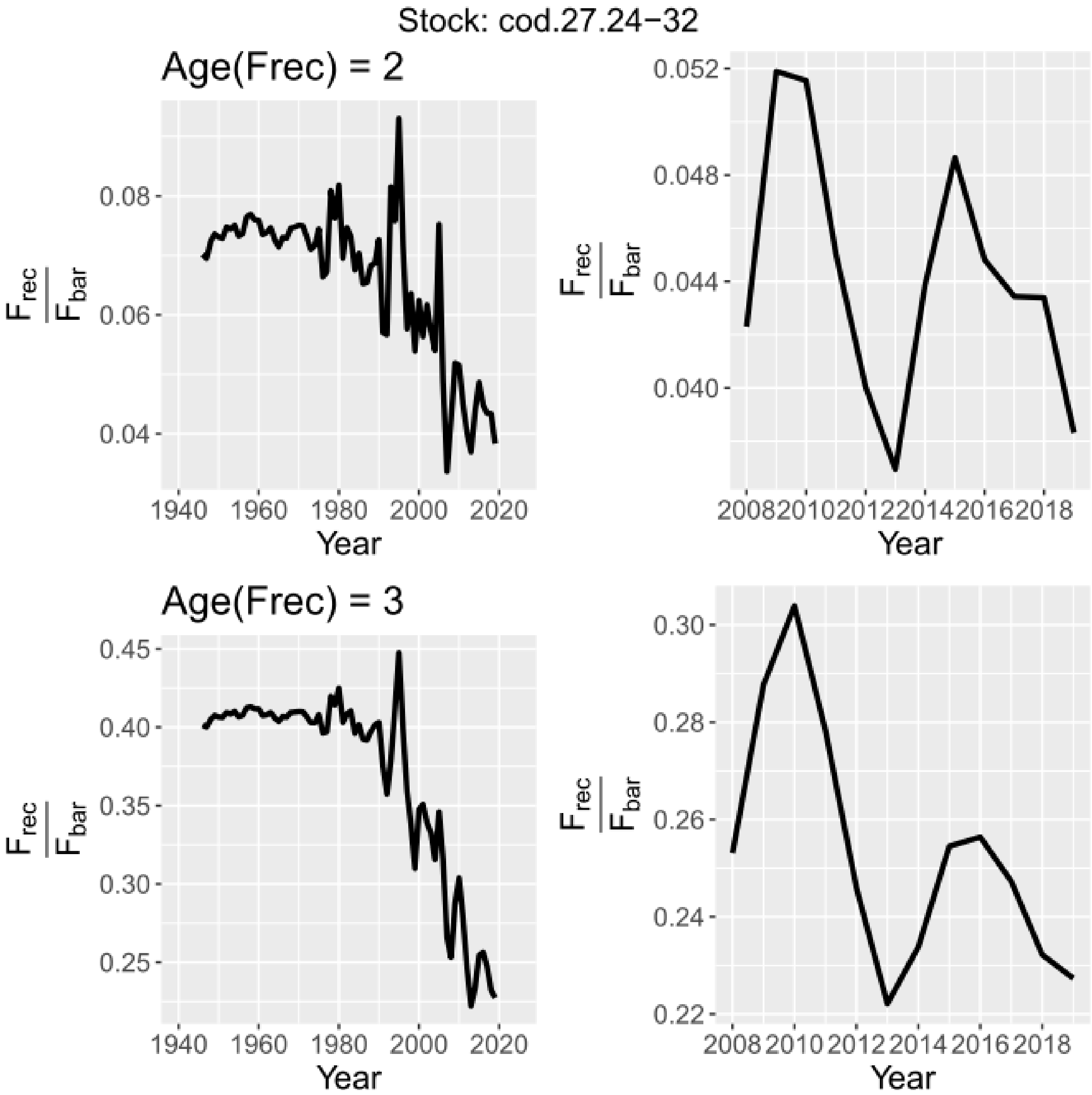

Figure 5: Eastern Baltic cod stock. Time-series of the selectivity indicator F_{rec}/F_{bar}. Left: full time series; Right: reduced time series.

Both indicators have been stable over the first part of the time-series, whereas a decreasing trend, with fluctuations, can be seen over the last two and a half decades. When looking at the last 10 years, both indicators behave the same, with large fluctuations and slight decreasing trends.

The relevant/major technical measures influencing the cod fishery in the Baltic are given in

5. The technical measures, which have changed over the last 10 years, comprise of the following categories:

a) Species and size selectivity of fishing gear (EU 1241/2019 Article 16)

b) Closed or restricted areas to protect juveniles and spawning aggregations (EU 1241/2019 Article 17)

c) Changes in MCRS (EU 1396/2014)

d) Introduction of Landing obligation (EU 1396/2014)

a) The selectivity measures, applied especially to the Baltic mixed trawl fishery aimed mainly at improving the size selectivity of both Baltic cod stocks. In 2010, there was a significant change in selectivity in the fishery, when the codend mesh size (stretched mesh opening) was increased from 110mm to 120mm. During the period 2010 to 2019, only minor gear related changes in technical measures with little influence on the size selectivity of cod were implemented (introduction of Swedish T90 codend (optional)). Therefore, it cannot be expected that the changes could have caused substantial changes in the indicator chosen. Apart from the gear related technical measures, there are anecdotal reports about changes in gear selectivity in the fishery to circumvent the significant catch loss caused by using a larger mesh when the abundance of large fish decreased in the mid 2010s.

b) Spawning closures for Baltic cod stocks were already implemented since the late 1990s, but with varying spatial and temporal extent. Spawning closures were implemented during the period 2010-2019 to protect the spawning of the Eastern Baltic cod stock. The temporal and spatial extent of these spawning closures was changed several times during this period (see

5). Due to the expected low direct effect of spawning closures on the chosen selectivity indicator and due to the inconsistent implementation, no conclusion can be drawn using this methodology about the effectiveness of these spawning closures.

As the main potential effect of a spawning closure is aimed to be a better recruitment of the stock, the effect on the selectivity indicator is assumed to be lower. Nevertheless, the separation of small fish and spawning fish during the spawning season might result in more clean catches of larger fish on spawning grounds in years when the fishery can target spawning aggregations, resulting in a reduction of the selectivity indicator.

c) In 2015, the MCRS changed for both Baltic cod stocks from 38 cm to 35 cm. Together with the introduction of the landing obligation (d), this change should have reduced the amount of cod catches below MLS/MCRS and hence discards (before 2015) or below MCRS-catches (after 2015). As this measure merely changes the assignment of catches to under or over MLS/MCRS, it is not expected to change the actual catch profiles and thus not affect the chosen indicator.

d) Also in 2015, the landing obligation was introduced for Baltic cod stocks. To make the landing obligation an effective measure to improve the cod stocks in the Baltic, sufficient enforcement is required. The introduction of the landing obligation also changed the willingness of the fishery to contribute to sufficient catch sampling, directly influencing the quality of the estimate of F_{rec}.

In summary, numerous changes in technical measures were implemented between 2010 and 2019 - some of them potentially conflicting and/or not sufficiently enforced. Therefore - and given the uncertainties in the underlying F-estimates - it is not possible to infer causal relationships between changes in the selectivity indicator and any specific changes in technical measures.

Plaice SD21-23

General stock trends

The following stock summary is taken from ICES advice (ICES 2020d).

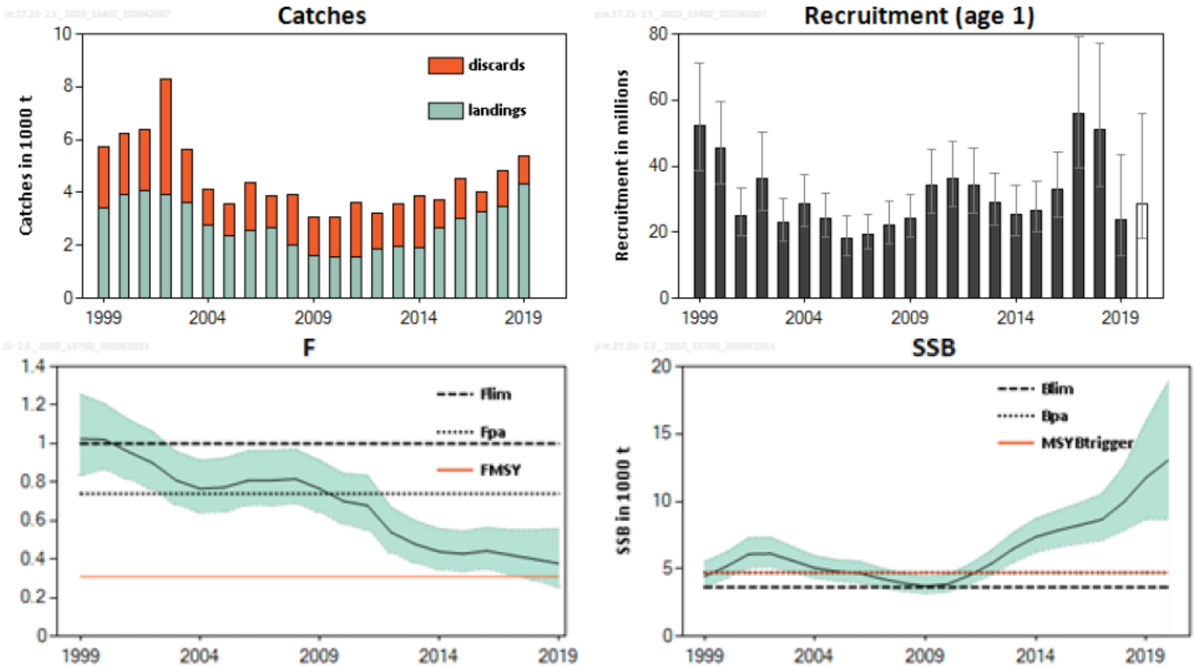

Figure 6: Baltic Plaice stock in subdivision 21-23. Summary of the stock assessment. Recruitment, F and SSB show confidence intervals (95%) in the plot. BMS landings (fish below the minimum conservation reference size [MCRS]) have been included since 2017. Figure taken from ICES 2020d.

The spawning-stock biomass (SSB) has increased significantly from 2009, and has been above MSY Btrigger since 2012. Fishing mortality (F) has declined since 2008, but F remains above FMSY. Recruitment has fluctuated without trends between 1999 and 2016 and there are two large year classes in 2017 and 2018.

The EU landing obligation has covered plaice in the Baltic (subdivisions (SDs) 22–32) from January 2017 onwards. The implementation has been gradual in the Kattegat (SD 21), but the main fisheries have been included from 2019 onwards. Landings of fish below the MCRS are very low (13 t BMS were reported in 2018), and discarding still takes place. The estimated discard amount, 1387 tonnes in 2018 (approximately 29%), is based on observer data.

Quality of the assessment

According to ICES (2020b), the quality of the assessment has declined in 2020, probably due to anomalous conditions during the Q4 BITS survey leading to large reductions in the tuning indices. Because of these anomalous conditions a secondary assessment, with the relevant survey indices removed, has been presented to and accepted by WGBFAS.

In conclusion, the uncertainty of the assessment implies that the estimates of F-at-age, used for the indicators, are also quite uncertain.

Selectivity indicator

We looked at two versions of the selectivity indicator F_{rec}/F_{bar} , using age classes 1 or 2 for F_{rec} and age classes 3-5 for F_{bar}. The corresponding length-at-age are given in Table 4, along with MCRS.

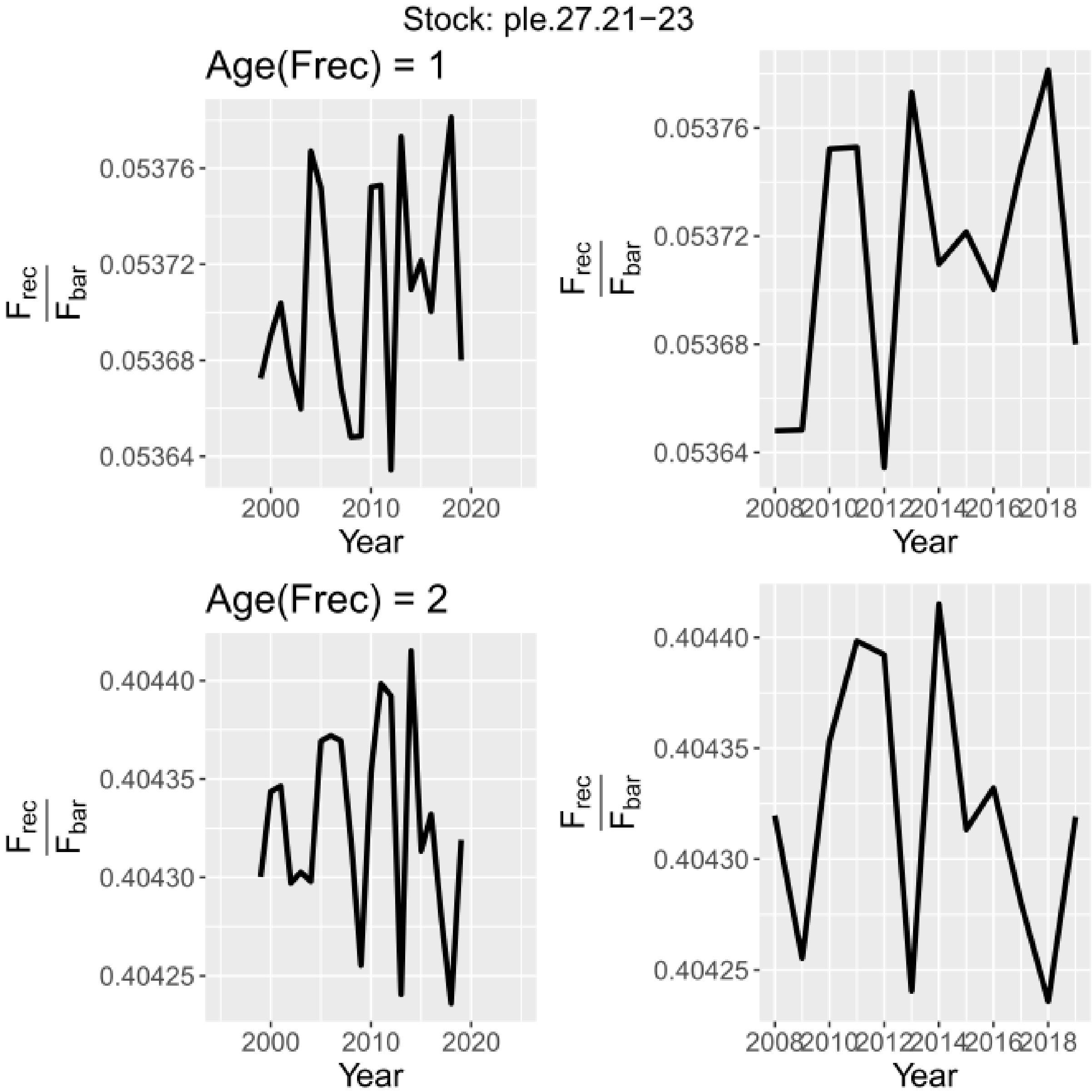

Figure 7: Baltic Plaice Stock in SD21-23. Time-series of Selectivity indicator Frec/Fbar. Left: full time series; Right: reduced time series.

Considering the extremely small magnitude of the fluctuations (check the values on the y-axis), we can say that the indicators remained stable over the whole time series. The relevant/major technical measures influencing the fishery in the Baltic are given in

5. The technical measures relevant to plaice in this area comprise of the following categories:

a) Species and size selectivity of fishing gear (EU 2019/1241 Article 16)

b) Closed or restricted areas to protect juveniles and spawning aggregations of Baltic cod (Article 17)

c) Introduction of Landing obligation (EU 2014/1396)

a) The selectivity measures, applied especially to the Baltic mixed trawl fishery aimed mainly at improving the size selectivity of Baltic cod. In 2010, there was a significant change in selectivity in the fishery, when the codend mesh size (stretched mesh opening) was increased from 110mm to 120mm. During the period 2010 to 2019, only minor changes in technical measures with little influence on the size selectivity of plaice were implemented. Therefore, it cannot be expected that the changes could have caused substantial changes in the indicator chosen. Apart from the gear related technical measures, there are anecdotal reports about changes in gear selectivity in the fishery to circumvent the significant loss of cod catches caused by using a larger mesh when the abundance of large fish decreased in the mid 2010's.

b) Spawning closures for Baltic cod stocks, which potentially causes changes in fishing pattern - potentially relevant also for plaice - were already implemented since the late 1990s, but with varying spatial and temporal extent. Spawning closures were implemented during the period 2010-2019 to protect the spawning of the Western Baltic cod stock. The temporal and spatial extent of these spawning closures was changed several times during this period (see

5). Due to the expected low direct effect of spawning closures on the chosen selectivity indicator and due to the inconsistent implementation, no conclusion can be drawn using this methodology about the effect of these spawning closures on plaice.

c) The EU landing obligation has covered plaice in the Baltic (subdivisions (SDs) 22–32) from January 2017 onwards. The implementation has been gradual in the Kattegat (SD 21), but the main fisheries have been included from 2019 onwards. To make the landing obligation an effective measure to improve the plaice stocks in the Baltic, sufficient enforcement is required. The introduction of the landing obligation also changed the willingness of the fishery to contribute to sufficient catch sampling, directly influencing the quality of the estimate of F_{rec}.

In summary, numerous changes in technical measures were implemented between 2010 and 2019 - some of them potentially conflicting and/or not sufficiently enforced. Therefore - and given the uncertainties in the underlying F-estimates - it is not possible to infer causal relationships between the absence of changes in the selectivity indicator and changes in technical measures.

Plaice SD24-32

General stock trends

The following stock summary is taken from ICES advice (ICES 2020e).

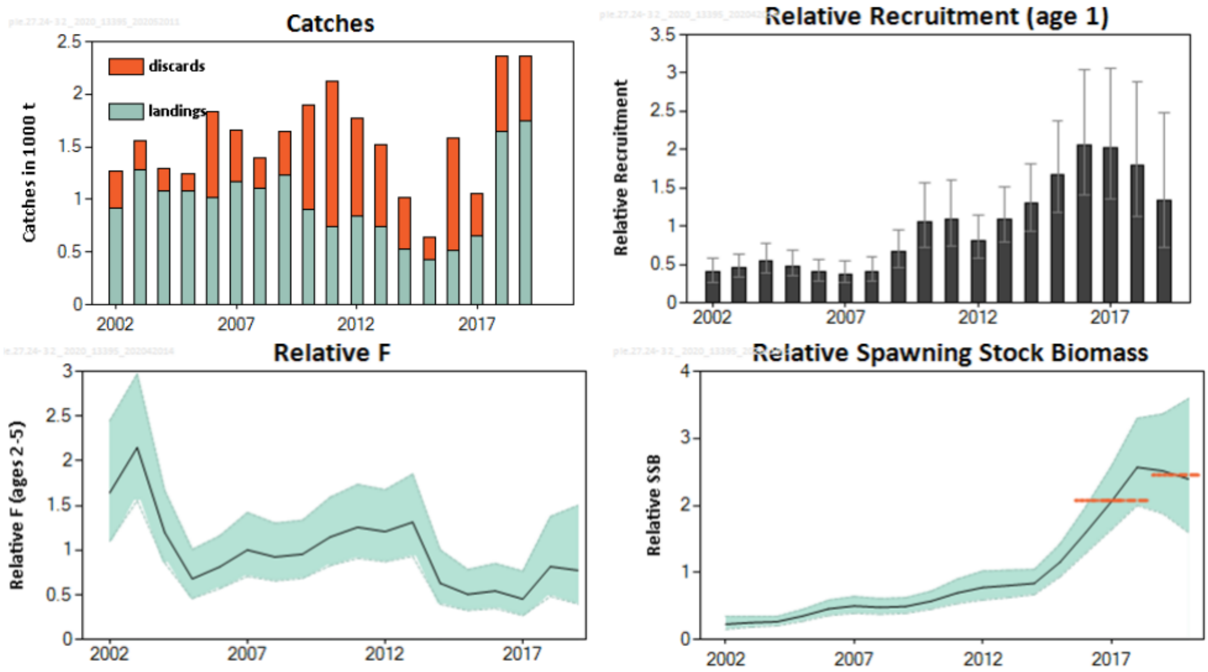

Figure 8: Baltic Plaice stock in subdivision 24-32. Summary of the stock assessment. Recruitment, F and SSB show confidence intervals (95%) in the plot. BMS landings (fish below the minimum conservation reference size [MCRS]) have been included since 2017. Figure taken from ICES 2020e.

The assessment is indicative of trend only. The relative spawning-stock biomass (SSB) has been increasing significantly since 2014. Relative recruitment was high in 2016 and 2017 but is slightly decreasing since then. The relative fishing mortality has been fluctuating in recent years.

The EU landing obligation has covered plaice in the Baltic (subdivisions (SDs) 22–32) from January 2017 onwards. Landings of fish below the MCRS are very low (8.6 tonnes below MCRS [BMS] reported in 2018), and discarding still takes place despite the fact that the landing obligation has been in place since 2017. The estimated discard amount of 720 tonnes in 2018 (approximately 30.5%) is based on observer data.

Quality of the assessment

According to ICES (2020), the stock is categorized as a Category 3.2 Data Limited Stock (DLS). In conclusion, the uncertainty of the assessment implies that the estimates of F-at-age, used for the indicators, are also quite uncertain.

Selectivity indicator

The selectivity indicator F_{rec}/F_{bar} used age class 1 for F_{rec} and age classes 2-5 for F_{bar}. The corresponding length-at-age are given in Table 4, along with MCRS.

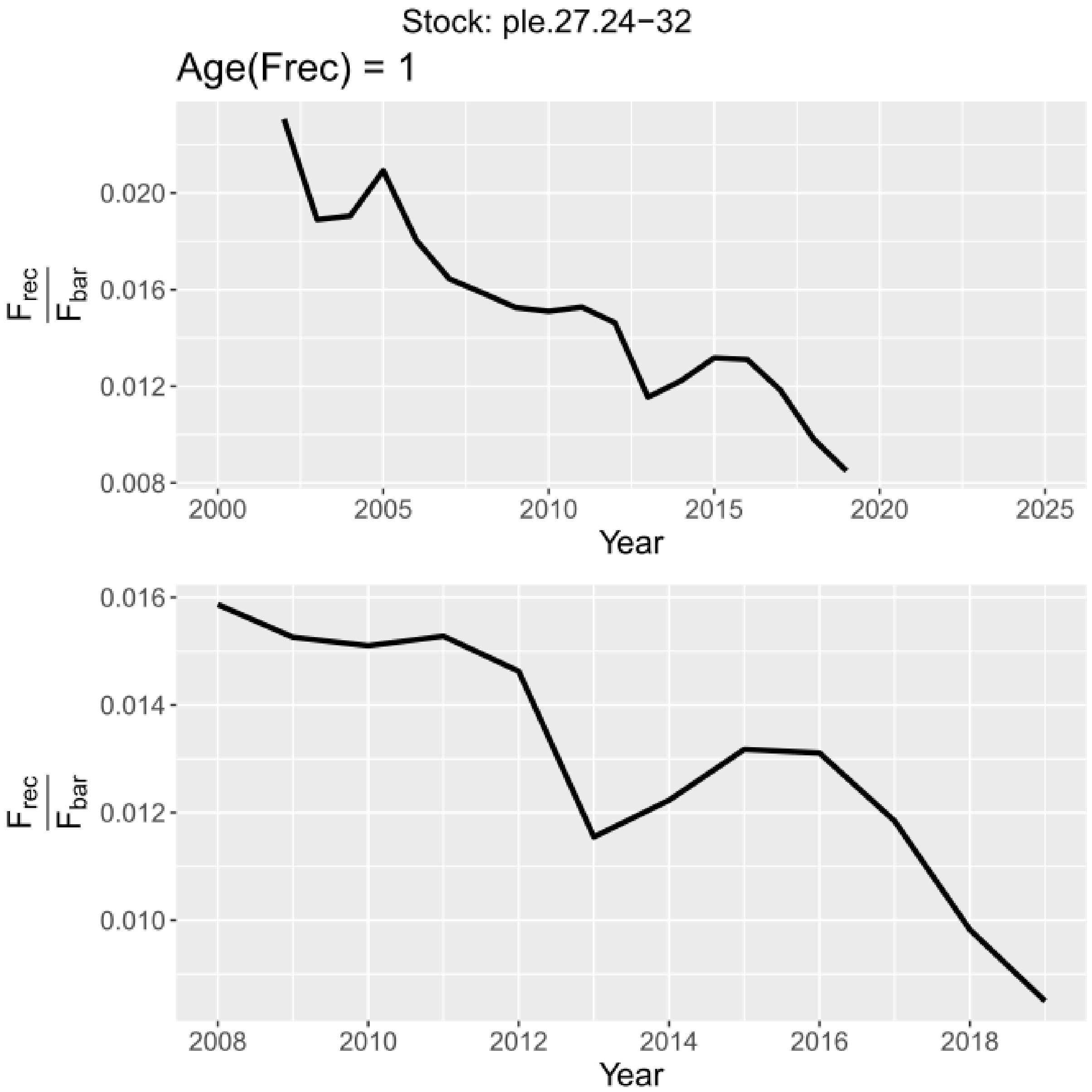

Figure 9: Baltic Plaice in SD24-32. Time-series of Selectivity indicator F_{rec}/F_{bar}. Top: full time series; Bottom: reduced time series.

Overall, since the beginning of the time series, the indicator has more than halved, which indicates an improvement in selectivity. Looking at the last 10 years, the indicator drops in 2013, goes up again and drops again from 2016 onwards. The relevant/major technical measures influencing the mixed fishery in the Baltic are given in

5. The technical measures, relevant for plaice comprise of the following categories:

a) Species and size selectivity of fishing gear (EU 2019/1241 Article 16)

b) Closed or restricted areas to protect juveniles and spawning aggregations (EU 1241/2019 Article 17)

c) Introduction of Landing obligation (EU 2014/1396)

a) The selectivity measures, applied especially to the Baltic mixed trawl fishery aimed mainly at the improvement of the size selectivity of Baltic cod. In 2010, there was a significant change in selectivity in the fishery, when the codend mesh size (stretched mesh opening) was increased from 110mm to 120mm. During the period 2010 to 2019, only minor changes in technical measures with little influence on the size selectivity of cod were implemented. Therefore, it cannot be expected that the changes could have caused substantial changes in the indicator chosen. Apart from the gear related technical measures, there are anecdotal reports about changes in gear selectivity in the fishery to circumvent the significant catch loss caused by using a larger mesh when the abundance of large fish decreased in the mid 2010s.

b) Spawning closures for Baltic cod stocks, which potentially cause changes in fishing pattern - potentially relevant also for plaice - were already implemented since the late 1990s, but with varying spatial and temporal extent. Spawning closures were implemented during the period 2010-2019 to protect the spawning of the Western Baltic cod stock. The temporal and spatial extent of these spawning closures was changed several times during this period (see

5). Due to the expected low direct effect of spawning closures on the chosen selectivity indicator and due to the inconsistent implementation, no conclusion can be drawn using this methodology about the effect of these spawning closures on plaice.

c) The EU landing obligation has covered plaice in the Baltic (subdivisions (SDs) 22–32) from January 2017 onwards. To make the landing obligation an effective measure to improve the plaice stocks in the Baltic, sufficient enforcement is required. The introduction of the landing obligation also changed the willingness of the fishery to contribute to sufficient catch sampling, directly influencing the quality of the estimate of F_{rec}.

In summary, numerous changes in technical measures were implemented between 2010 and 2019 - some of them potentially conflicting and/or not sufficiently enforced. Therefore - and given the uncertainties in the underlying F-estimates - it is not possible to infer causal relationships between any specific changes in the selectivity indicator and changes in technical measures.

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North Sea

This study focuses on five North Sea stocks: cod, haddock, saithe, whiting and plaice.

Summary North Sea

The selectivity indicator shows a gradual decreasing trend over the longer term for the roundfish species cod and saithe pointing at a gradual improvement of selectivity over time and thus an increasing protection of juveniles. With the indicator at low level for both species at the end of the time series and being at an all-time minimum we can conclude that the objective to protect juveniles has been achieved without finding correlations that can be attributed to technical measures.

Haddock and whiting show a quite variable indicator track over the span of the time series. For haddock the indicator has risen over the last few years and ends up at a relatively high level compared to the mean of the time series. For this species it cannot be concluded that the objective to protect juveniles has be reached. For whiting, on the other hand, the indicator is close to an all-time low during the most recent years indicating protection of juveniles. No correlations between the indicator and technical measures could be established.

Each of the four roundfish species show an almost simultaneous but slight rise of the indicator during the last 2 or 3 years which may be worth investigating.

For plaice, the only flatfish species in the analysis of the North Sea, the indicator is highly variable over the whole time series. The value of the indicator is on average also rather high pointing at a relative high pressure on juveniles. The most recent years the indicator has dropped, although to an average level. It cannot be concluded that juvenile plaice are adequately protected and no clear correlations have been found between the indicator and technical measures.

The main relevant changes in technical measures are listed in Table 5.

Table 5: Changes of technical measures, applied to North Sea fisheries – selection of relevant measures for the period 1998 to 2020

Sea basin	Technical measure	Year	Measure	Species of interest	Pros/Cons	EU reg no
North Sea	Species and size selectivity	1998	Technical Measures Regulation consolidates the mesh size in the North Sea for whiting at 80mm	Whiting		
North Sea	Species and size selectivity	2002	Mesh size increased to 110 mm for North Sea gadoid fisheries. Restrictions on gear construction and specific measures for certain fisheries (beam trawls and gillnets). The use of 80-99mm mesh size still permitted in the southern North Sea and eastern Channel in the directed whiting fishery.	Whiting		
North Sea	Species and size selectivity	2002	Mesh size increased to 110 mm for West of Scotland and North Sea gadoid fisheries. Catches with mesh sizes in the range of 110 to 119 mm containing at least 70 % of saithe subject to a bycatch limit of no more than 3 % of cod.	Saithe, cod	No SMP required	
North Sea	Species and size selectivity	2004	Introduction of first cod effort management plan, which included a provision to allow increased fishing effort when using selective gears.	Cod	Limited uptake.	
North Sea	Species and size selectivity	2008	German vessels move to 120mm in the saithe fishery.	Saithe, cod	Voluntary uptake	
North Sea	Species and size selectivity	2008	First introduction of Conservation Credit Scheme in the United Kingdom (UK) (real-time closures—RTCs) which reduced effort in areas of high concentrations of juveniles.	Cod, haddock, whiting, saithe	Uptake limited to a small number of Scottish vessels.	
North Sea	Species and size selectivity	2009	Cod effort management plan which further incentivized the use of selective gears	Cod, haddock, whiting, saithe	Increased uptake particularly in the UK as part of the Conservation Credit Scheme	Revised Conservation Credit Scheme in the UK (RTCs)
North Sea	Species and size selectivity	2009	Revised Conservation Credit Scheme in the UK (RTCs). The use of more selective gears was made mandatory for UK vessels in certain fisheries with whiting and haddock bycatch.	Whiting, haddock		
North Sea	Species and size selectivity	2011	Real-time closures introduced into the North Sea and Skagerrak under .	Whiting	Limited uptake reported	Regulation (EU) 724/2010 and

						783/2011
North Sea	Species and size selectivity	2015	New technical measures introduced into the Skagerrak to increase the mesh size to 120mm with specific derogations for the Nephrops mixed demersal fish/Nephrops and Pandalus fisheries. Selective devices (e.g. Seltra and sorting grids) made mandatory in these fisheries.	Cod, haddock	Only for Skagerrak	
North Sea	Species and size selectivity	2016	EU/Norway management strategy for saithe adopted	Saithe		
North Sea	Species and size selectivity	2017	De minimis exemption for sole under the LO in the North Sea linked to use of large mesh panels placed in the bottom part of beam trawls to release undersized sole. This "Flemish panel" in beam trawl fishery was made mandatory for Dutch and Belgium vessels.	Sole, (plaice)	The scientific support for the Flemish panel is available but limited in terms of season and gear type	
North Sea	Species and size selectivity	2018	Use of the SEP net to reduce unwanted catches of plaice in the Nephrops fishery introduced under the North Sea discard plan.	Plaice	Uncertain to what extent this has been taken up by the industry.	
North Sea	Landing Obligation	2018	All catches of cod subject to the Landing Obligation.	Cod	De minimis exemption for cod and whiting introduced in 70-99mm fisheries in 4c.	Regulation (EU) 2018/44
North Sea	Landing Obligation	2018	All catches of haddock subject to the Landing Obligation.	Haddock		Regulation (EU) 2018/45
North Sea	Landing Obligation	2018	All catches of whiting subject to the Landing Obligation in area 4 (Regulation (EU) 2018/45). De minimis in the mixed demersal fishery in 4c introduced which includes provision for discarding of unwanted catches of whiting.	Whiting		
North Sea	Landing Obligation	2018	All catches of saithe where the total landings per vessel consisted of more than 50 % of saithe are subject to the Landing Obligation.	Saithe		
North Sea	Species and size selectivity	2019	New technical measures framework Regulation (Reg. (EU) 1241/2019) establishes a baseline mesh size for the North Sea of 120mm.	Saithe		Regulation (EU) 1241/2019

North Sea	Species and size selectivity	2019	All catches of whiting subject to the Landing Obligation in 7d (Regulation 46/2018) where total landings per vessel of all species consisted of more than 10 % of the following gadoids: cod, haddock, whiting and saithe combined. De minimis introduced to allowed discarding of unwated catches in mixed demersal fisheries in 7d.	Whiting		
North Sea	Landing Obligation	2019	All catches of saithe subject to the Landing Obligation.	Saithe		
North Sea	Landing Obligation	2019	All catches of plaice subject to the Landing Obligation. Survival exemption introduced to allow discarding of unwanted catches of plaice. Uptake by Dutch vessels.	Plaice		
North Sea	Closed or restricted areas	2020	Remedial measures to protect cod in the form of seasonal closures introduced into the North Sea to protect cod under. The rule to overcome the measure are in effect !	Cod		Regulation (EU) 123/2020
North Sea	Species and size selectivity	2009-2021	Gradual increasing use of the flatfish pulse trawl by the Dutch beam trawl fleet with evidence of differences in spatial fishing activity, increased catching efficiency for sole and lower catching efficiency for plaice.	Plaice	Pulse trawl has reduced catching efficiency for plaice compared to beam trawl	

North Sea cod

General stock trends

The following stock summary is taken from ICES advice (ICES 2020a).

Fishing mortality (F) has increased since 2016 and is above Flim in 2018. Spawning-stock biomass (SSB) has decreased since 2015 and is now below Blim. Recruitment since 1998 remains poor. ICES assess that fishing pressure on the stock is above FMSY, Fpa, and Flim; the spawning-stock size is below MSY Btrigger, Bpa, and Blim.

The EU landing obligation was implemented from 1 January 2017 for several gears, including otter trawlers with >100 mm mesh (TR1), beam trawlers >120 mm mesh (BT1), and fixed gears. From 2018, cod is fully under the EU landing obligation in Subarea 4 and Subdivision 20. The EU landing obligation did not apply to cod in Division 7.d in 2018. The below minimum size (BMS) landings of cod reported to ICES are currently negligible and are much lower than the estimates of catches below the minimum conservation reference size (MCRS) estimated by observer programmes.

It is uncertain whether if, and to what extent, the discontinuation of the days-at-sea regulation in 2017, which was part of the cod recovery plan, has an impact on the recent decline of the cod stock.

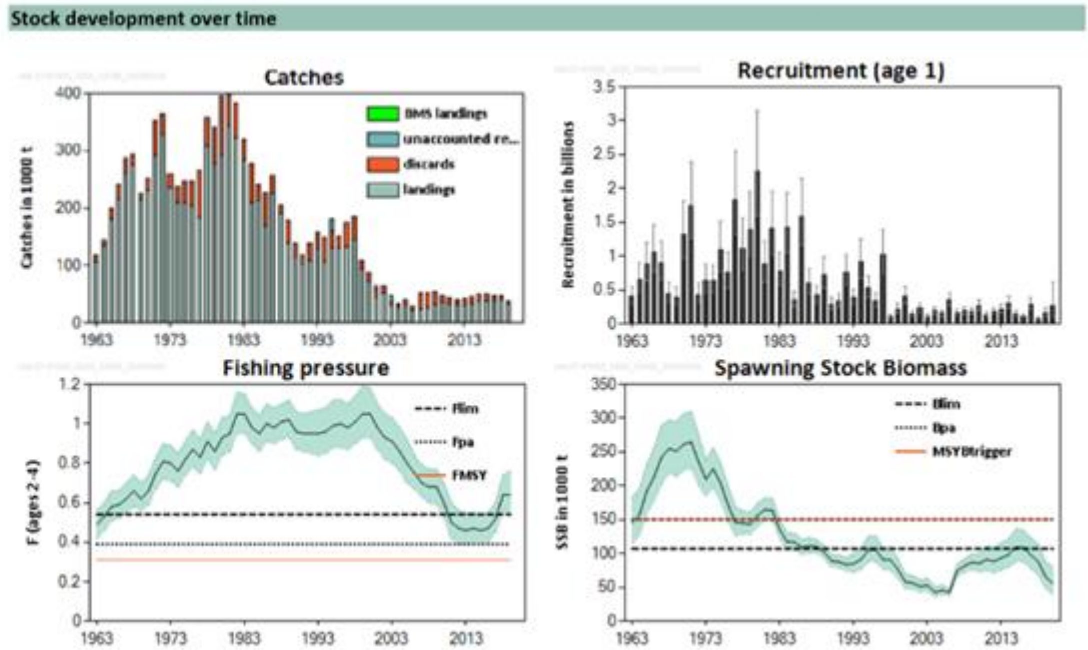

Figure 10: North Sea cod. Summary of the stock assessment. Recruitment, F and SSB show confidence intervals (95%) in the plot. Figure taken from ICES 2020a.

The timeline of the technical measures and other changes that could have potentially affected the selectivity of this stock is as follows:

- 1980 – First EU/Norway Shared Stocks Agreement signed which includes haddock in the North Sea.
- 1983—First EU Technical Measures Regulation established minimum mesh sizes and restrictions on the construction and use of trawl gears. As part of this regulation the mesh size increased from 80 mm in 1983 to 90 mm in 1984.

- 1983-2005 – Steady decline in SSB
- 1986—Revised Technical Measures Regulation increased mesh size for gadoid fisheries.
- 1998 onwards – Recruitment has been very low.
- 1998 – Revised Technical Measures Regulation consolidates the mesh size in the North Sea at 100mm for gadoid fisheries
- 2001 – Closure to protect spawning cod introduced for one year
- 2002—Mesh size increased to 110 mm for North Sea gadoid fisheries. Restrictions on gear construction and specific measures for certain fisheries (beam trawls and gillnets).
- 2002 – ICES advise closure of the cod fishery
- 2003—Further increase in mesh size for gadoid fisheries to 120 mm.
- 2004-2007 – ICES advise zero catch of North Sea cod
- 2004—Introduction of first cod effort management plan, which included a provision to allow increased fishing effort when using selective gears. Limited uptake.
- 2008—First introduction of Conservation Credit Scheme in the United Kingdom (UK) (real-time closures—RTCs) which reduced effort in areas of high concentrations of juveniles. Uptake limited to a small number of Scottish vessels.
- 2009—Introduction of second cod effort management plan which further incentivized the use of selective gears in return for increased effort allocations. Increased uptake particularly in the UK as part of the Conservation Credit Scheme
- 2009—Revised Conservation Credit Scheme in the UK (RTCs). The use of more selective gears was made mandatory for UK vessels in certain fisheries with haddock bycatch.
- 2011/2012 – Real-time closures introduced into the North Sea and Skagerrak under Regulation (EU) 724/2010 and 783/2011. Limited uptake reported
- 2015 – New technical measures introduced into the Skagerrak to increase the mesh size to 120mm with specific derogations for the Nephrops mixed demersal fish/Nephrops and Pandalus fisheries. Selective devices (e.g. Seltra and sorting grids) made mandatory in these fisheries.
- 2018 – North Sea MAP adopted, and cod plan repealed. Effort restrictions removed.
- 2018— All catches of cod subject to the Landing Obligation (Regulation (EU) 2018/45). De minimis exemption for cod and whiting introduced in 70-99mm fisheries in 4c.
- 2019 – ICES advice 63% reduction in cod TAC
- 2019 – New technical measures framework Regulation (Reg. (EU) 1241/2019) establishes a baseline mesh size for the North Sea of 120mm.
- 2020 – Remedial measures to protect cod in the form of seasonal closures introduced into the North Sea to protect cod under Regulation (EU) 123/2020. The rule to overcome the measure are in effect
- 2020 – Further remedial measures introduced in amendment to Regulation (EU) 123/2020 including additional closures and the use of selective gears

Selectivity indicator

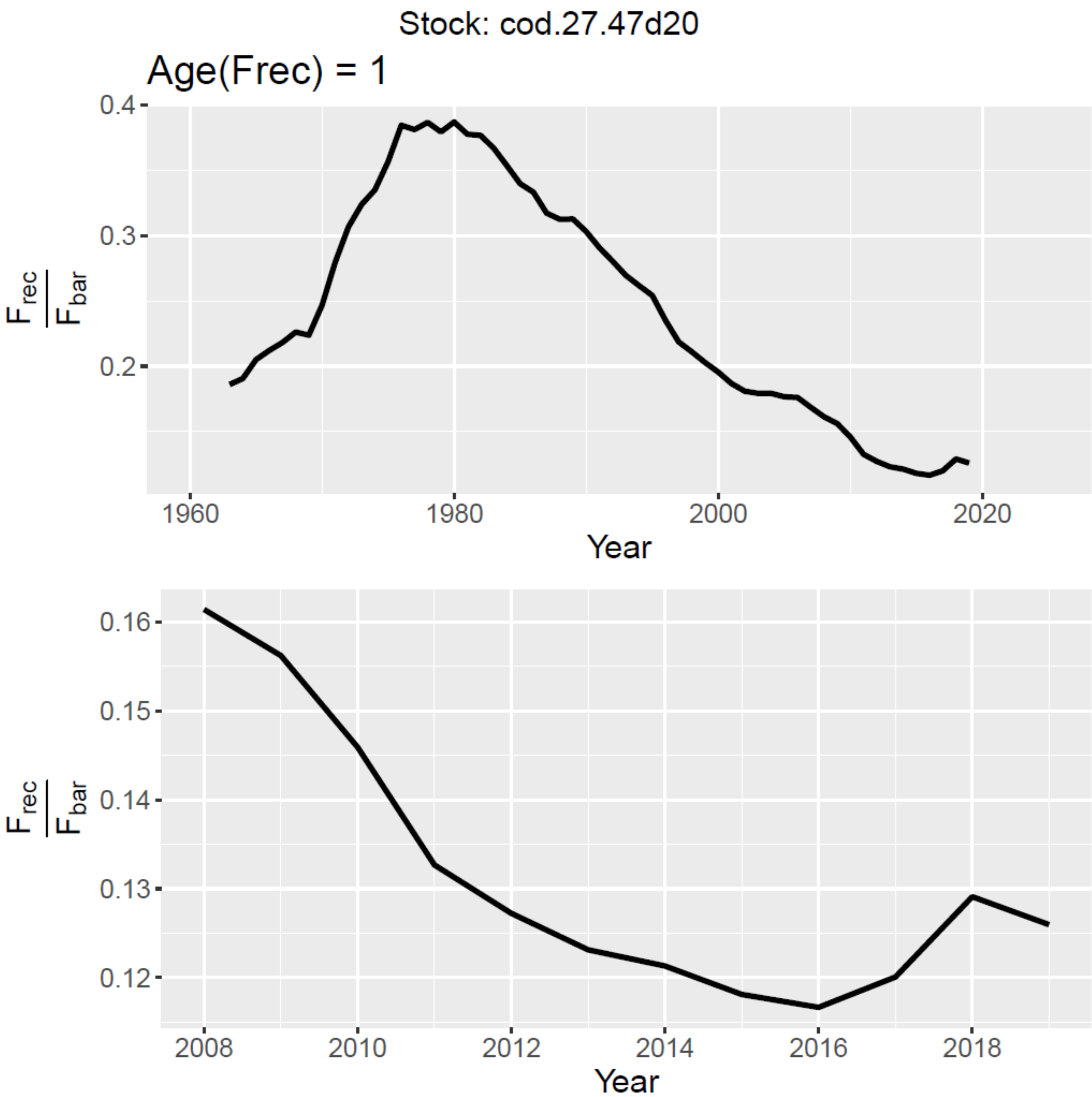

Figure 11: North Sea cod. Time-series of Selectivity indicator F_{rec}/F_{bar}. Top: full time series; Bottom: reduced time series.

The selectivity indicator starts reasonably low at the beginning of the time series halfway through the 1960's. It then rises quite steeply to a maximum of 0.4 halfway the 1970's. From 1980 onwards the indicator shows a gradual improvement in selectivity. The indicator drops below its initial value of 0.2 from the year 2000 onwards. The evolution of the indicator points at a gradual improvement of the selectivity for the young fish after 1980 with a slight deterioration since 2016.

The introduction of the cod effort management plan in 2009 (a) aimed to incentivise the use of more selective fishing gears. There was a further change in selectivity in 2015 when new technical measurers were introduced into the Skagerrak (b). There is evidence that the selectivity of these gears, namely the Seltra, was modified after its introduction

(Krag et.al. 2016). Therefore, it is difficult to determine whether such changes in the technical measures have resulted in any changes in the selectivity indicator.

There is a slight increase in the indicator during the last few years of the time series that is also observed for haddock, saithe and whiting.

Achievement of objective and targets (Article 3 and 4)

The indicator suggests a trend of improving selectivity with less fishing pressure on juvenile cod and an improved exploitation pattern. However, EWG 20-02 cannot identify whether this is related to changes in technical measures or reflects changes in fishing patterns.

North Sea haddock

General stock trends

The following stock summary is taken from ICES advice (ICES 2020a).

Fishing mortality (F) has declined since the beginning of the 2000s, but it has been above FMSY for the entire time-series. Spawning-stock biomass (SSB) has been above MSY Btrigger in most of the years since 2002. Recruitment since 2000 has been low with occasional larger year classes. The 2019-year class is estimated to be the largest since 2000. ICES assess that fishing pressure on the stock is above FMSY but below Fpa and Flim, and that spawning stock size is above MSY Btrigger, Bpa, and Blim.

The EU landing obligation has been phased in to all catches of haddock in ICES Subarea 4 since 2016. Since 2019, the stock is fully under the EU landing obligation. Landings of fish below the minimum conservation reference size (MCRS) are very low and discarding still takes place. The estimated discard amount in 2018 was 4895 tonnes (12.4%), based on observer data.

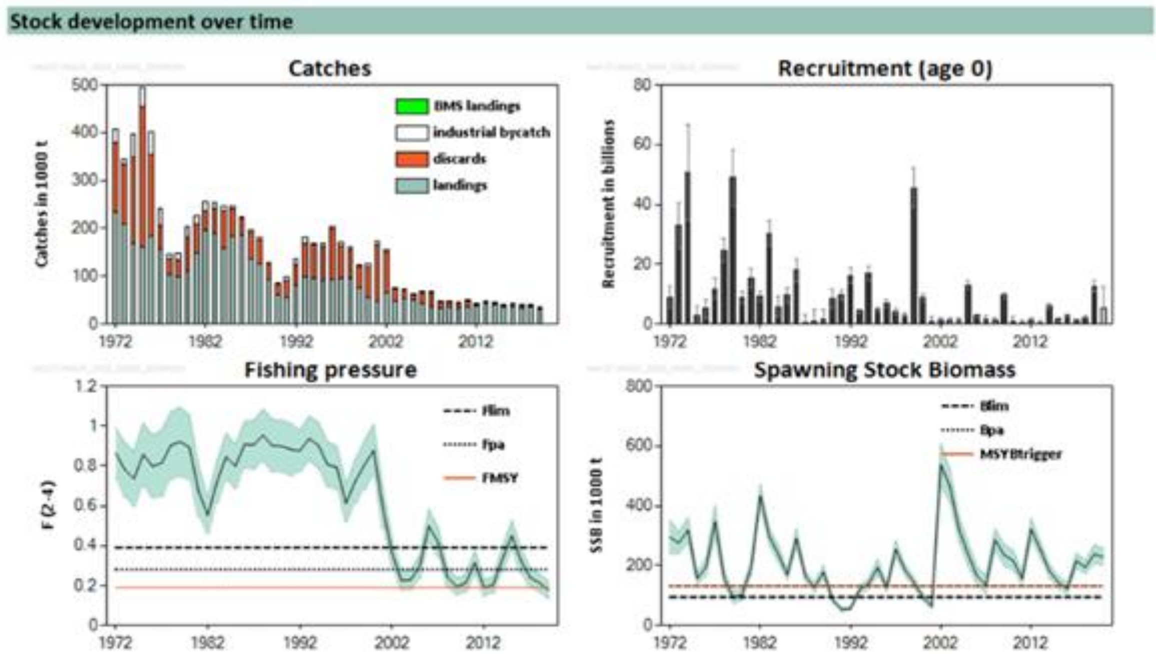

Figure 12: North Sea haddock. Summary of the stock assessment. Recruitment, F and SSB show confidence intervals (95%) in the plot. Figure taken from ICES 2020b.

The timeline of the technical measures and other changes that could have potentially affected the selectivity of this stock is as follows:

- 1980 – First EU/Norway Shared Stocks Agreement signed which includes haddock in the North Sea.
- 1983—First EU Technical Measures Regulation established minimum mesh sizes and restrictions on the construction and use of trawl gears. As part of this regulation the mesh size increased from 80 mm in 1983 to 90 mm in 1984.
- 1986—Revised Technical Measures Regulation increased mesh size for gadoid fisheries.
- 1998 – Revised Technical Measures Regulation consolidates the mesh size in the North Sea at 100mm for gadoid fisheries
- 2002—Mesh size increased to 110 mm for North Sea gadoid fisheries. Restrictions on gear construction and specific measures for certain fisheries (beam trawls and gillnets).
- 2003—Further increase in mesh size for gadoid fisheries to 120 mm.
- 2004—Introduction of first cod effort management plan, which included a provision to allow increased fishing effort when using selective gears. Limited uptake.
- 2008—First introduction of Conservation Credit Scheme in the United Kingdom (UK) (real-time closures—RTCs) which reduced effort in areas of high concentrations of juveniles. Uptake limited to a small number of Scottish vessels.
- 2009—Introduction of second cod effort management plan which further incentivized the use of selective gears in return for increased effort allocations. Increased uptake particularly in the UK as part of the Conservation Credit Scheme
- 2009—Revised Conservation Credit Scheme in the UK (RTCs). The use of more selective gears was made mandatory for UK vessels in certain fisheries with haddock bycatch.
- 2011/2012 – Real-time closures introduced into the North Sea and Skagerrak under Regulation (EU) 724/2010 and 783/2011. Limited uptake reported
- 2015 – New technical measures introduced into the Skagerrak to increase the mesh size to 120mm with specific derogations for the Nephrops mixed demersal fish/Nephrops and Pandalus fisheries. Selective devices (e.g. Seltra and sorting grids) made mandatory in these fisheries.
- 2018 – North Sea MAP adopted, and cod plan repealed.
- 2018— All catches of haddock subject to the Landing Obligation (Regulation (EU) 2018/45).
- 2020 – Remedial measures to protect cod in the form of seasonal closures introduced into the North Sea to protect cod under Regulation (EU) 123/2020
- 2020 – Further remedial measures introduced in amendment to Regulation (EU) 123/2020 including additional closures and the use of selective gears

Selectivity indicator

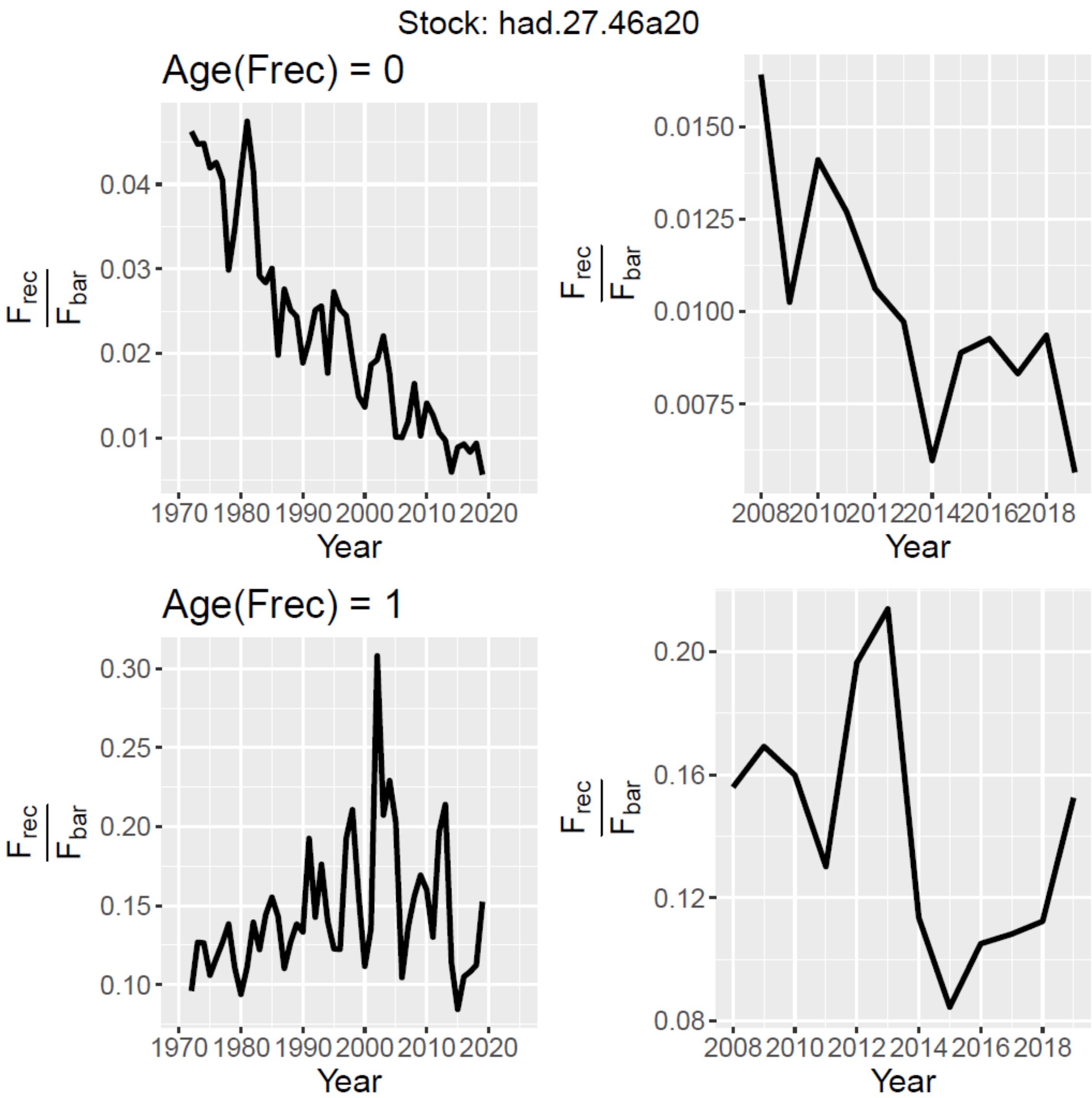

Figure 13: North Sea haddock. Time-series of Selectivity indicator F_{rec}/F_{bar}. Top (Frec = 0) left: full time series; Top right: reduced time series ; Bottom (Frec = 1) left: full time series; Bottom right: reduced time series.

The selectivity indicator based on Frec for age 0 shows very low values over the entire time series indicating a high selectivity for that age class. The mesh sizes of the gears catching haddock are thus sufficiently large to protect the youngest age. The difference in the indicator over the time series is quite low in absolute numbers, there is a consistent downward (improving) trend.

The selectivity indicator based on Frec for age 1, with values between 0.1 and 0.3, indicates that that age class partially ends up in the catch. The time series starts at a value around 0.1 in 1970, increases to reach a maximum around the year 2000 and then decreases again to end up around at a similar value as at 2008. The curve shows high variability over the period 2008 - 2019. This indicator reached an absolute minimum in

2015 but increases over the last 4 years. There is no definitive explanation of this deterioration in selectivity and it is more than likely due to changes in fishing patterns.

Since haddock is a well-known by-catch in cod fisheries, one might expect that the cod effort management plan could have a beneficial effect on haddock. This is, however, not clear from the data. The increase in minimum mesh size and selective devices in technical measure (b) in 2015 does not seem to have a detectable effect and the same can be said for the landing obligation introduced in 2018. The removal of the effort restrictions may have contributed to the recent rise of the indicator.

There is a slight increase in the indicator during the last few years of the time series that is also observed for cod, saithe and whiting.

Achievement of objective and targets (Article 3 and 4)

The objective to protect juveniles would appear not to have been reached and the variability of the indicator makes it difficult to assess whether this as a consistent effect. The indicator did reach an all-time minimum in 2015 but rose sharply after. However, there is no clear linkage to technical measures.

North Sea saithe

General stock trends

The following stock summary is taken from ICES advice (ICES 2020a).

Spawning-stock biomass (SSB) has fluctuated without trend and has been above MSY Btrigger since 1996. Fishing mortality (F)has decreased and stabilized at or below FMSY since 2014. Recruitment (R) has shown an overall decreasing trend over time with lowest levels in the past 10 years. ICES assess that fishing pressure on the stock is at FMSY and below Fpa and Flim; spawning-stock size is above MSY Btrigger, Bpa and Blim.

Below minimum size (BMS) landings reported to ICES in 2016–2018 were low. In 2018, saithe catches in all EU fleets of Subarea 4 and Division 3.a were subject to the EU landing obligation, with a de minimis exemption for saithe caught in crustacean fisheries. In Subarea 6, saithe was subject to the landing obligation in fisheries targeting saithe. Substantial discarding still continues in Subarea 4, based on observations from sampling programmes (estimated unwanted catch for 2018 is 7649 tonnes in Subarea 4 and Division 3.a, i.e. 8.7% of the total catch).

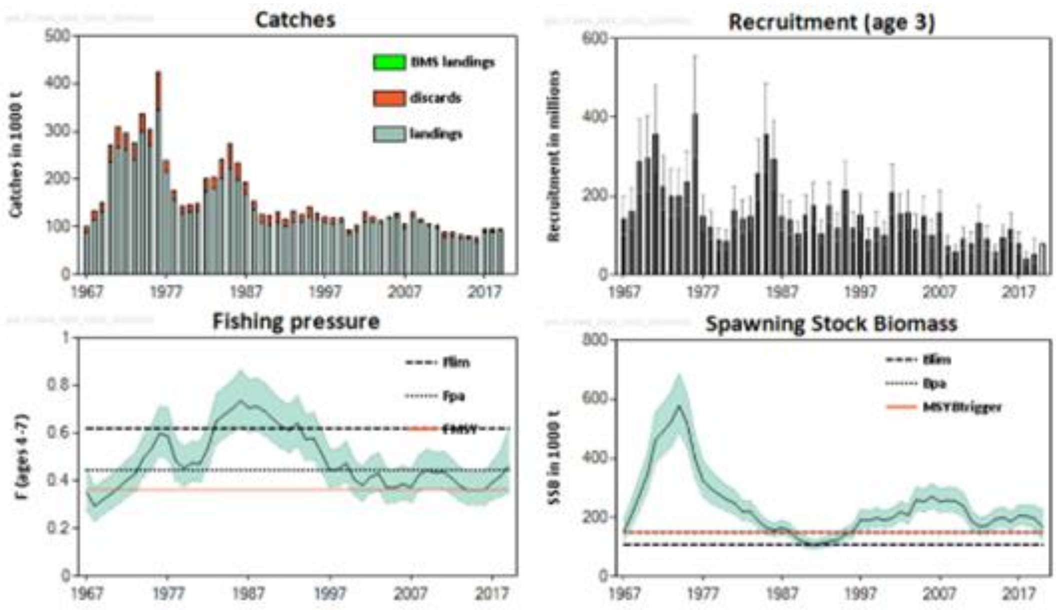

Figure 14: North Sea saithe. Summary of the stock assessment. Recruitment, F and SSB show confidence intervals (95%) in the plot. Figure taken from ICES 2020d.

The timeline of the technical measures and other changes that could have potentially affected the selectivity of this stock is as follows:

- 1983—First EU Technical Measures Regulation established minimum mesh sizes and restrictions on the construction and use of trawl gears. As part of this regulation the mesh size increased from 80 mm in 1983 to 90 mm in 1984.
- 1986—Revised Technical Measures Regulation increased mesh size for gadoid fisheries.
- 2002—Mesh size increased to 110 mm for West of Scotland and North Sea gadoid fisheries. Catches with mesh sizes in the range of 110 to 119 mm containing at least 70 % of saithe subject to a bycatch limit of no more than 3 % of cod. No SMP required.
- 2004—Introduction of first cod effort management plan, which included a provision to allow increased fishing effort when using selective gears. Limited uptake.
- 2008—First introduction of Conservation Credit Scheme in the United Kingdom (UK) (real-time closures—RTCs) which reduced effort in areas of high concentrations of juveniles. Uptake limited to a small number of Scottish vessels.
- 2008 – German vessels move to 120mm in the saithe fishery voluntarily.
- 2009—Introduction of second cod effort management plan which further incentivized the use of selective gears in return for increased effort allocations. Increased uptake particularly in the UK as part of the Conservation Credit Scheme
- 2009—Revised Conservation Credit Scheme in the UK (RTCs). The use of more selective gears was made mandatory for UK vessels in certain fisheries.
- 2009—Introduction of emergency technical measures. Mesh size increased to 120 mm with 120 mm square mesh panels in bottom trawl (TR)1 fisheries (i.e., towed gears with a codend mesh size of greater or equal to 100 mm) and 80 mm plus 120 mm square mesh panels or sorting grid in TR2 fisheries (i.e., towed gears with a codend mesh size in the range of 79–99 mm). Gillnetting for gadoids prohibited. Measures only applied in area inside the continental shelf and saithe fisheries largely unaffected. Vessels continued to fish with mesh size of 1

- 2011/2012 – Real-time closures introduced into the North Sea and Skagerrak under Regulation (EU) 724/2010 and 783/2011. Limited uptake reported
- 2016 – EU/Norway management strategy for saithe adopted.
- 2018 – North Sea MAP adopted, and cod plan repealed. Effort restrictions removed.
- 2018 - All catches of saithe where the total landings per vessel consisted of more than 50 % of saithe are subject to the Landing Obligation.
- 2019 – All catches of saithe subject to the Landing Obligation.
- 2019 – New technical measures framework Regulation (Reg. (EU) 1241/2019) establishes a baseline mesh size for the North Sea of 120mm.
- 2020 – Remedial measures to protect cod in the form of seasonal closures introduced into the North Sea to protect cod under Regulation (EU) 123/2020
- 2020 – Further remedial measures introduced in amendment to Regulation (EU) 123/2020 including additional closures and the use of selective gears

Selectivity indicator

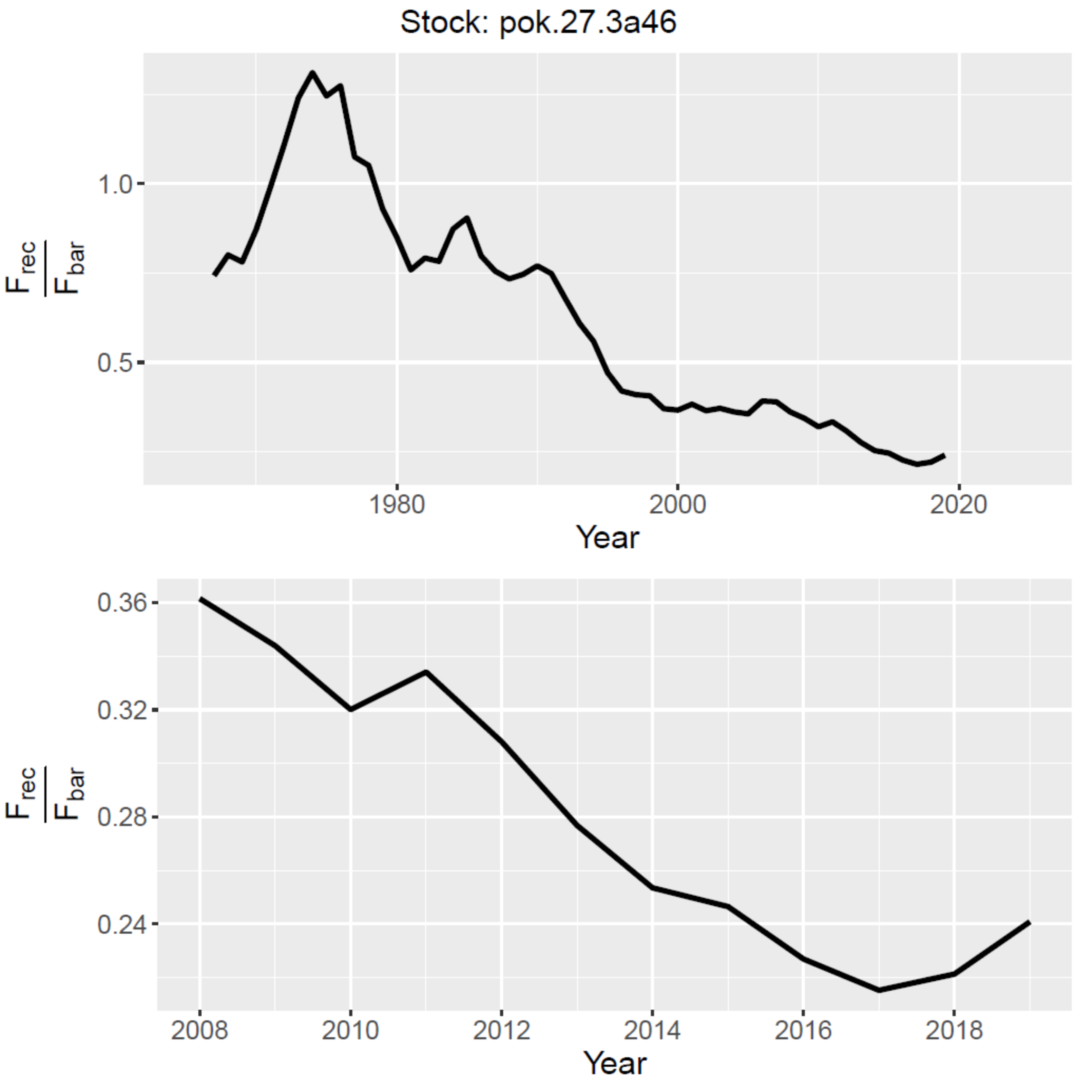

Figure 15: North Sea saithe. Time-series of Selectivity indicator F_{rec}/F_{bar}. Top: full time series; Bottom: reduced time series.

The selectivity indicator starts around 0.75 at the beginning of the time series at the end of the 1960’s. It then rises quite steeply to a maximum of 1.3 halfway the 1970’s to start its gradual downward slope until present. The indicator drops below its initial value of 0.75 from the year 1995 onwards. The evolution of the indicator points at a gradual improvement of the selectivity for the young fish after 1995 with a slight deterioration since 2017.

None of the technical measures seem to have a clear effect on the indicator.

There is a remarkable slight increase in the indicator during the last few years of the time series that is also observed for haddock, cod and whiting.

Achievement of objective and targets (Article 3 and 4)

The indicator suggests a trend of improving selectivity with less fishing pressure on juvenile saithe and an improved exploitation pattern. However, EWG 20-02 cannot identify whether this is related to changes in technical measures or reflects changes in fishing patterns.

North Sea Whiting

General stock trends

The following stock summary is taken from ICES advice (ICES 2020a).

Age-based analytical assessment (SAM; ICES, 2019b) that uses catches in the model and in the forecast

Spawning-stock biomass (SSB) has fluctuated around MSY Btrigger since the mid-1980s and is just below it in 2019. Fishing mortality (F) has been above FMSY throughout the time-series, apart from 2005. Recruitment (R) has been fluctuating without trend, but the last two-year classes are below average. An EU multiannual management plan (MAP) has been agreed by the EU for this stock (EU, 2018).

Since 2018, whiting catches in all fleets (including TR2, BT2) of Subarea 4 and Division 7.d are subject to the landing obligation, with a de minimis exemption for whiting caught with bottom trawls in Division 4.c. Substantial discarding still continues, based on observations from sampling programmes (estimated unwanted catch in 2018 is 9942 tonnes, which is 38% of the human consumption fishery catch). To maximize the benefit for the fishery of this stock, the most obvious measure would be to improve the selection pattern and reduce catches of undersized fish.

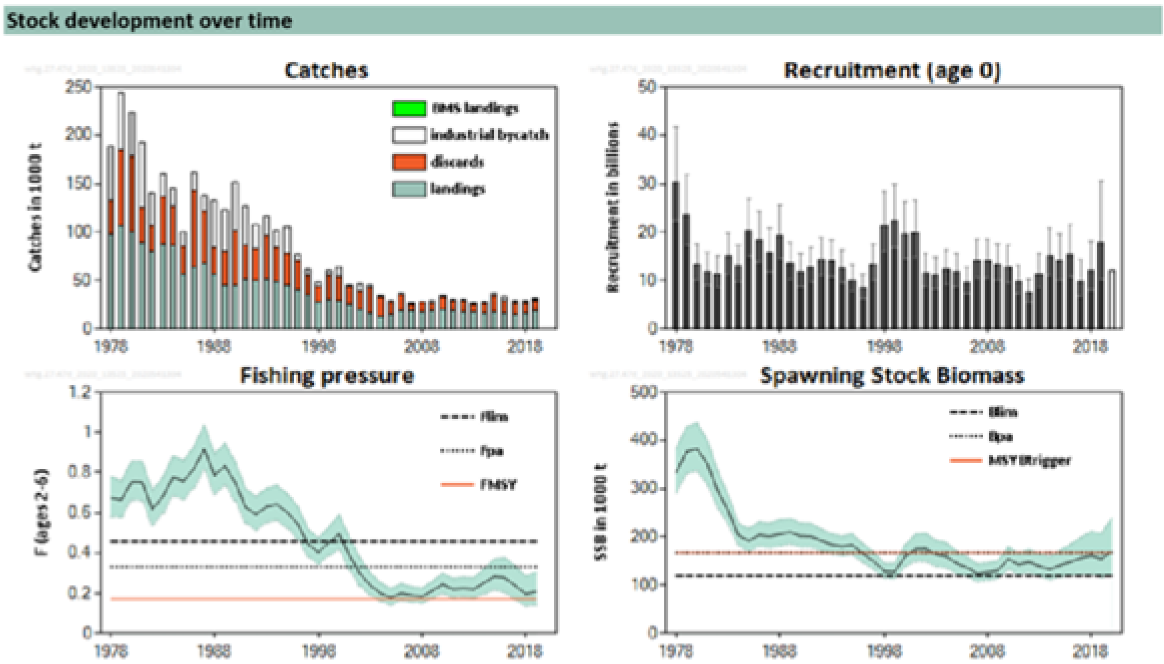

Figure 16: North Sea whiting. Summary of the stock assessment. Recruitment, F and SSB show confidence intervals (95%) in the plot. Figure taken from ICES 2020e.

The timeline of the technical measures and other changes that could have potentially affected the selectivity of this stock is as follows:

- 1998 – Technical Measures Regulation consolidates the mesh size in the North Sea for whiting at 80mm
- 2002—Mesh size increased to 110 mm for North Sea gadoid fisheries. Restrictions on gear construction and specific measures for certain fisheries (beam trawls and

gillnets). The use of 80-99mm mesh size still permitted in the southern North Sea and eastern Channel in the directed whiting fishery.

- 2004—Introduction of first cod effort management plan, which included a provision to allow increased fishing effort when using selective gears. Limited uptake.
- 2008—First introduction of Conservation Credit Scheme in the United Kingdom (UK) (real-time closures—RTCs) which reduced effort in areas of high concentrations of juveniles. Uptake limited to a small number of Scottish vessels.
- 2009—Introduction of second cod effort management plan which further incentivized the use of selective gears in return for increased effort allocations. Increased uptake particularly in the UK as part of the Conservation Credit Scheme
- 2009—Revised Conservation Credit Scheme in the UK (RTCs). The use of more selective gears was made mandatory for UK vessels in certain fisheries with whiting and haddock bycatch.
- 2011/2012 – Real-time closures introduced into the North Sea and Skagerrak under Regulation (EU) 724/2010 and 783/2011. Limited uptake reported
- 2018 – North Sea MAP adopted, and cod plan repealed. Effort restrictions removed.
- 2018— All catches of whiting subject to the Landing Obligation in area 4 (Regulation (EU) 2018/45). De minimis in the mixed demersal fishery in 4c introduced which includes provision for discarding of unwanted catches of whiting.
- 2019 – All catches of whiting subject to the Landing Obligation in 7d (Regulation 46/2018) where total landings per vessel of all species consisted of more than 10 % of the following gadoids: cod, haddock, whiting and saithe combined. De minimis introduced to allowed discarding of unwated catches in mixed demersal fisheries in 7d.
- 2020 – Remedial measures to protect cod in the form of seasonal closures introduced into the North Sea to protect cod under Regulation (EU) 123/2020
- 2020 – Further remedial measures introduced in amendment to Regulation (EU) 123/2020 including additional closures and the use of selective gears

Selectivity indicator

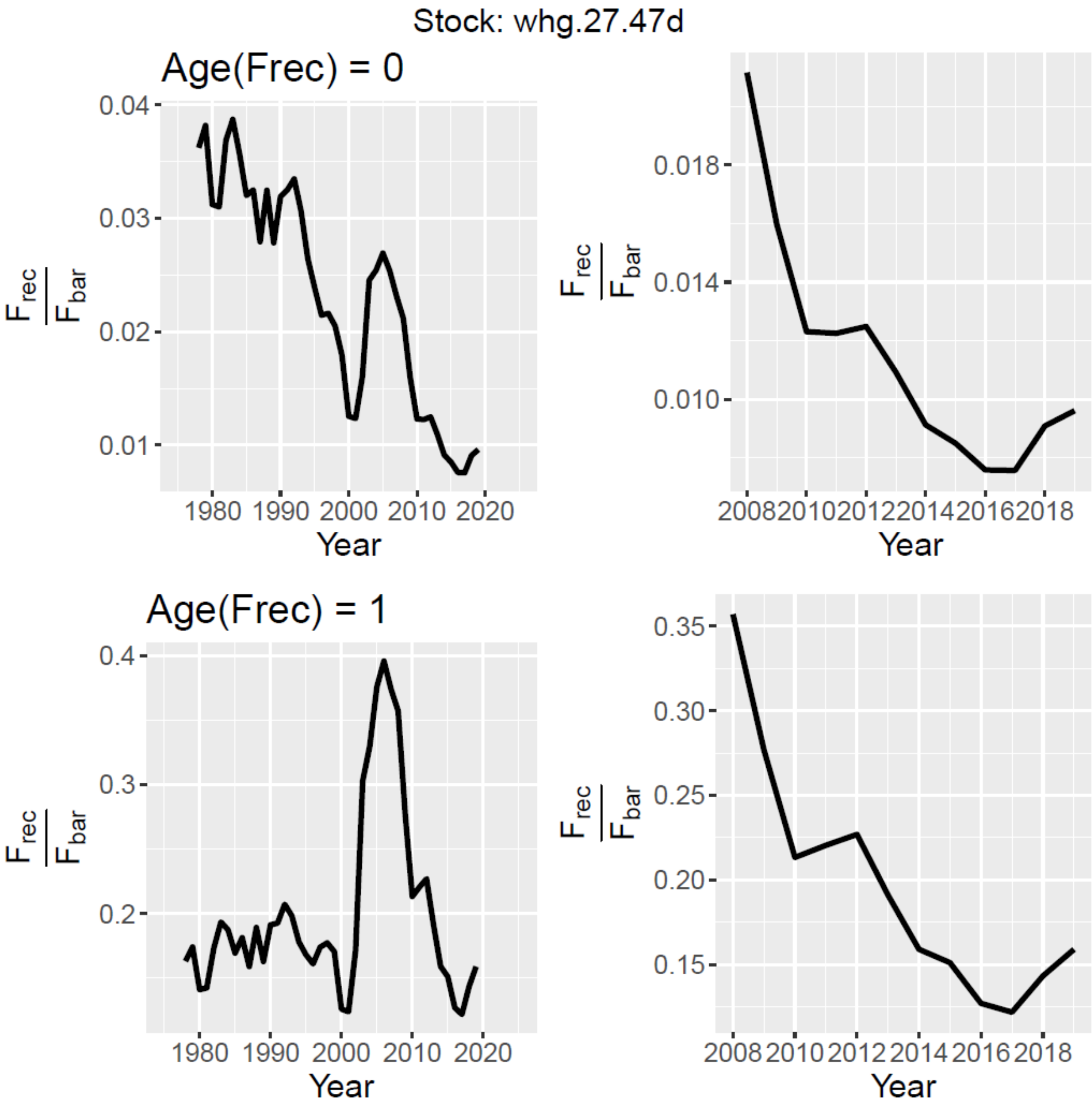

Figure 17: North Sea whiting. Time-series of Selectivity indicator F_{rec}/F_{bar}. Top (Frec = 0) left: full time series; Top right: reduced time series ; Bottom (Frec = 1) left: full time series; Bottom right: reduced time series.

The selectivity indicator based on Frec for age 0 shows very low values over the entire time series indicating a high selectivity for that age class. The mesh sizes of the gears catching whiting are thus sufficiently large to protect the youngest age class. Although the difference over the time series is quite low in absolute numbers, there is consistent downward (thus improving), though quite variable, trend. As with haddock, catches of 0-group whiting are very low and this may not be good age class to use as Frec.

The selectivity indicator based on Frec for age 1, with values below 0.1 and up to 0.4, indicates that that age class partially ends up in the catch. The time series starts at a value around 0.1 at the end of the 1970s, stays quite stable until the year 2000 and then increases steeply to reach a maximum of 0.4 around the year 2006, representing a deterioration in selectivity. It then shows a gradual improvement from 2008 onwards. The indicator has shown a slight deterioration in selectivity over the last 2 years. The removal of effort restrictions may play a role in this.

Since whiting is a well-known by-catch in cod fisheries, one might expect that the cod effort management plan and the credit scheme in 2009 could have had a beneficial effect on whiting. Around that time, the indicator shows a steep drop indicating improved selectivity. The introduction of the landing obligation does not seem to have led to observable improvements in the indicator and the removal of the effort restrictions may have given to the reduction in selectivity shown by the indicator.

There is a slight increase in the indicator during the last few years of the time series that is also observed for cod, saithe and whiting.

Achievement of objective and targets (Article 3 and 4)

The objective to protect juveniles would appear to have been reached, although the variability of the indicator makes it difficult to assess whether this as a consistent effect. There seems to be some correlation between the indicator and the technical measures although this is not clear cut and the improvements are likely to be due to a combination of factors.

North Sea Plaice

General stock trends

The following stock summary is taken from ICES advice (ICES 2020a).

According to WGNSSK estimates, the North Sea is currently ongoing a plaice outburst without precedent. WGECO addressed the trends shown in the stock assessment of plaice, which show how increasing fishing pressure on the stock has progressively moved SSB away from the desired state (in the 1980s and 1990s), and then how management has rectified this situation in recent years, which has brought the North Sea plaice stock in a situation unlike any other over the whole 58 year period for which data is available.

SSB in 2019 is estimated around 1052 312 tonnes which is well above MSY Btrigger, Bpa, and Blim. Fishing mortality in 2019 is estimated to be at a value of 0.166 (below Fpa of 0.369, below the long-term management target F of 0.30 and below FMSY of 0.210).

There has been an exemption for plaice in the landing obligation based on high survival of discards until the end of 2020.

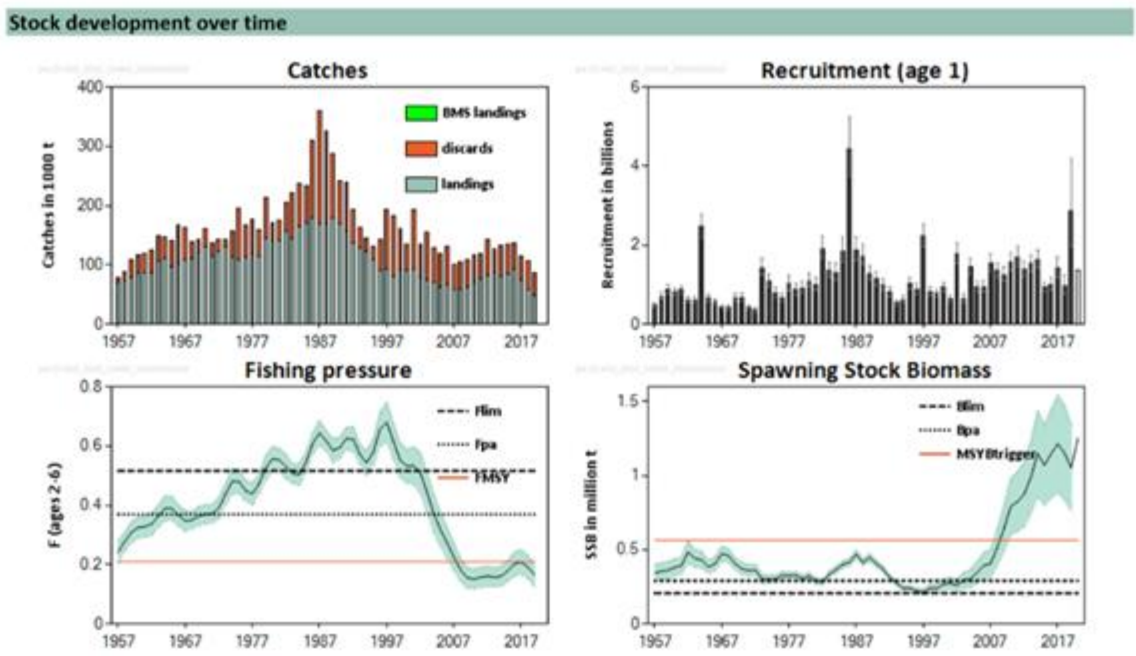

Figure 18: North Sea plaice. Summary of the stock assessment. Recruitment, F and SSB show confidence intervals (95%) in the plot. Figure taken from ICES 2020c.

The timeline of the technical measures and other changes that could have potentially affected the selectivity of this stock is as follows:

- 1990–1998—Codend mesh size for sole maintained at 80 mm under Regulation (EC) 850/98.
- 1989 – Plaice box introduced into the North Sea to reduce discarding of plaice box. Includes derogations for specific vessels.
- 2002—Increase in codend mesh size to 120 mm in beam trawl fisheries in the northern North Sea with a continuation of the use of 80 mm in the southern North

Sea. Derogation for 100mm-119mm mesh size for beam trawls in the directed plaice fishery in the Dogger Bank fishery

- 2004—Introduction of first cod effort management plan (effort limitations) which included provision to allow increased fishing effort when using selective gears. Limited uptake.
- 2007—Introduction of derogation to allow pulse trawls. Initial observations suggested that pulse trawls had a different gear selectivity than traditional beam trawls.
- 2007—Multiannual plan for sole and plaice introduced into the North Sea that aimed to reduce fishing mortality in the 80 mm beam trawl fishery for sole where discards of plaice were significant.
- 2009—Introduction of second cod effort management plan which incentivized the use of selective gears in return for increased effort allocations or removal from the effort regime altogether.
- 2009–2021—Increasing use of the pulse trawl by the Dutch beam trawl fleet with evidence of differences in spatial fishing activity.

Pulse trawl fishing started in 2009 and the use of pulse trawls in the main fishery operating in the North Sea has gradually increased and a fewer number of vessels operated with traditional beam trawls. Pulse gear allows the fishing of softer grounds and the spatial distribution of the main fisheries has shifted to the southern part of Division 4.c. A larger proportion of the sole catch is now taken in this area. Following the EU decision in February 2019 to revise the technical measures regulations, pulse gear will be prohibited from 30 June 2021 and is now being phased out (EU, 2019).

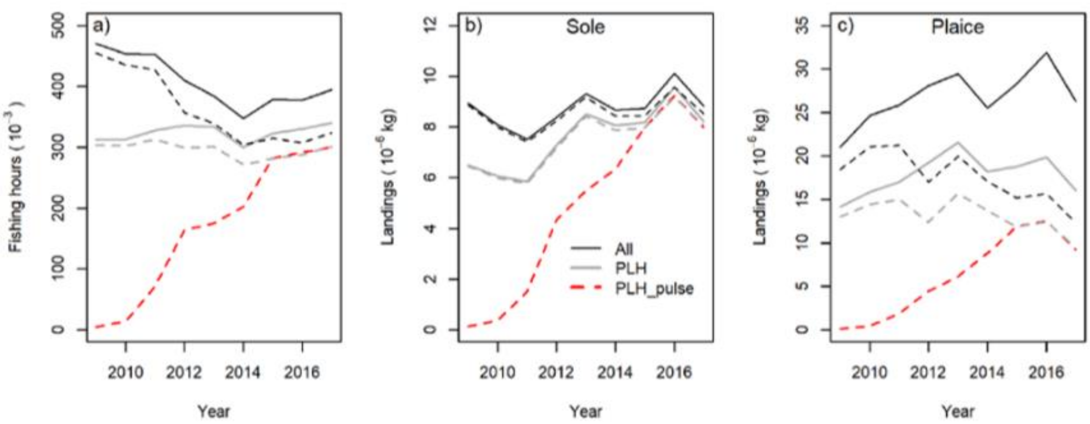

Figure 5.5. Evolution of fishing effort (a), sole landings (b) and plaice landings (c) of the total Dutch fleet of beam trawl vessels (ALL) and the subset of pulse license holders (PLH) in the North Sea areas IVc, IVb and Iva (full lines) and in the sole fishing area (SFA) between 51°N and 55°N west of 5°E and 56°N east of 5°E (dashed lines). The grey dashed lines show the data for the PLH using the tickler chain or pulse trawl. The red dashed line shows the results for the pulse trawl, only (Rijnsdorp et al., 2020a).

- 2017—De minimis exemption for sole under the LO in the North Sea linked to use of large mesh panels placed in the bottom part of beam trawls to release undersized sole. This "Flemish panel" in beam trawl fishery was made mandatory for Dutch and Belgium vessels.
- 2018 – Use of the SEP net to reduce unwanted catches of plaice in the Nephrops fishery introduced under the North Sea discard plan.

- 2019— All catches of plaice subject to the Landing Obligation. Survival exemption introduced to allow discarding of unwanted catches of plaice. Uptake by Dutch vessels.
- 2019 - New technical measures framework Regulation (Reg. (EU) 1241/2019) establishes a baseline mesh size for the North Sea of 120mm. Derogation for directed fishing for plaice and sole with trawls, seines and beam trawls to use 100mm with 90 mm SMP and maintains 80mm mesh size for beam trawls with 180mm headline panel and in 4c for trawls in directed sole fishery.

Selectivity indicator

Figure 19: North Sea plaice. Time-series of Selectivity indicator F_{rec}/F_{bar}. Top: full time series; Bottom: reduced time series.

The time series for indicator for plaice is very long beginning around 1950. The indicator shows an improving situation from 1960 to 1965 and then trends upwards (decline in selectivity) up until the late 1970s. For the period 1980 to 1995 the trend is downwards (improving selectivity). The indicator then shows a decline in selectivity up until 2009 corresponding to a large reduction in fishing mortality. After a consequent peak in 2014, the indicator drops to around 0.3 at present, similar to the beginning of the time series. Apart from the period between 2012 and 2014, the indicator shows an improving trend over the period 2008-2019 reflecting fairly stable fishing mortality and high SSB.

The time series indicates a relative high pressure on juvenile plaice throughout the whole period. By the end of the 1990s, when the fishing pressure on the plaice stock reached its maximum, the indicator reached a minimum. The indicator then rose gradually until the period when the multiannual plan for sole and plaice was introduced in 2007. This plan seemed to go together with a positive evolution of the indicator pointing at an increased protection of juveniles but soon the indicator rose again till 2014.The introduction of the flatfish pulse trawl targeting sole, with a lower efficiency for plaice, in 2009 may have contributed to the overall decrease in the indicator but this a rather speculation and impossible to disentangle from the other measures in that period. The more recent technical measures seem to go together with the positive evolution of the indicator until present although a clear relationship cannot be established. The indicator suggests the plaice box introduced in 1989 to reduce catches of juvenile plaice led to some positive impacts but this is not clear cut and the improvements seen may simply reflect changes in fishing patterns.

Achievement of objective and targets (Article 3 and 4)

The objective to protect juveniles has been reached during the last few years only, although the variability of the indicator makes it difficult to assess whether this as a consistent effect. There seems to be some correlation between the indicator and the technical measures although a causal correlation cannot be proven.

References

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ICES. 2020e. Whiting (Merlangius merlangus) in Subarea 4 and Division 7.d (North Sea and eastern English Channel). In Report of the ICES Advisory Committee, 2020. ICES Advice 2020, whg.27.47d. https://doi.org/10.17895/ices.advice.5935

West of Scotland

For the west of Scotland 4 stocks were considered cod, haddock, whiting and saithe. The major changes in technical measures associated with these stocks are shown in Table 6.

Table 6: Changes of technical measures, applied West of Scotland fisheries – selection of relevant measures for the period 2010 to 2001

Sea basin	Technical measure	Month	Year	Measure	Species of interest	Pros/Cons	EU reg no
West of Scotland	Closed or restrictive area		2001	Windsock cod closure	Cod	The extent of the closure is unlikely to be large enough to greatly reduce F in the 6a stock	456/2001
West of Scotland	Species and size selectivity	Jan	2002	Increase mesh size from 80 mm to 100 mm and use of 90mm square mesh panels	Cod, haddock, whiting, saithe	Improvement in selectivity for haddock and whiting but limited impact for cod and saithe	2056/2001
West of Scotland	Effort Restrictions	Jan	2004	First cod recovery plan. Linked the use of selective gears to increased effort	Cod indirectly haddock, whiting, saithe	Limited monitoring of uptake of selective gears. Numerous other selective gears added and multiple derogations available to avoid effort restrictions.	423/2004
West of Scotland	Real-time closures	Jan	2008	UK introduces Conservation Credit Scheme (Real-time closures) to reduce effort I areas of high concentrations of juvenile cod. Revised in 2009 to include selective gears to increase individual fishing effort allocation	Cod principally but indirectly haddock, whiting, saithe	Limited uptake by small number of vessels. Complex to monitor impacts	UK National legislation
West of Scotland	Species and size selectivity	Jan	2009	Mesh size increased to 120mm and 120mm smp in mixed demersal fisheries and 80mm and 120mm smp or sorting grid in *Nephrops* fisheries	Cod, haddock, whiting, saithe	Represented a significant in size selectivity in mixed demersal fisheries but limited monitoring too difficult to measure impact. Limited impact in *Nephrops* fisheries as vessels avoided using sorting grids	43/2009
West of Scotland	Effort Restrictions	Jan	2009	Second cod recovery plan. Incentivised the use of selective gear for increased effort or removal from the	Cod indirectly haddock, whiting, saithe	Complicated regulation	1342/2008

				effort regime			
West of Scotland	Closed or restricted areas		2013	Closed area to protected juvenile cod off Donegal	Cod	Initial analysis of impact of closed area but no monitoring once introduced	227/2013
West of Scotland	Species and size selectivity		2019	New technical measures Regulation introduces a minimum mesh size for gadoid fisheries of 120mm to be phased in by August 2021 for the whole of area 6	Cod, haddock, whiting, saithe	Unknown	1241/2019
West of Scotland	Landing Obligation	Jan	2019	All catches of cod, haddock, whiting and saithe subject to the Landing Obligation	Cod, haddock, whiting, saithe	Dependent on implementation	45/2018
West of Scotland	Landing Obligation	July	2020	New technical measures introduced in Nephrops fisheries (300mm smpand 100mm-119mm with 160mm smp)	Cod, haddock and whiting	Little impact on cod. Targeted mainly at reducing whiting and haddock. Litte impact on selectivity of cod. No impact on saithe	2239/2019
West of Scotland	Bycatch quota	Jan	2020	Bycatch quota set for cod and whiting. No directed fisheries allowed. Aligned with the Landing Obligation	Cod, whiting	TAC set above ICES advice (zero TAC). Unilkely to reduce fishing mortality. Assumes full monitoring of catches	123/2020

Cod 6a

General stock trends

The following stock summary is taken from ICES advice (ICES 2020a).

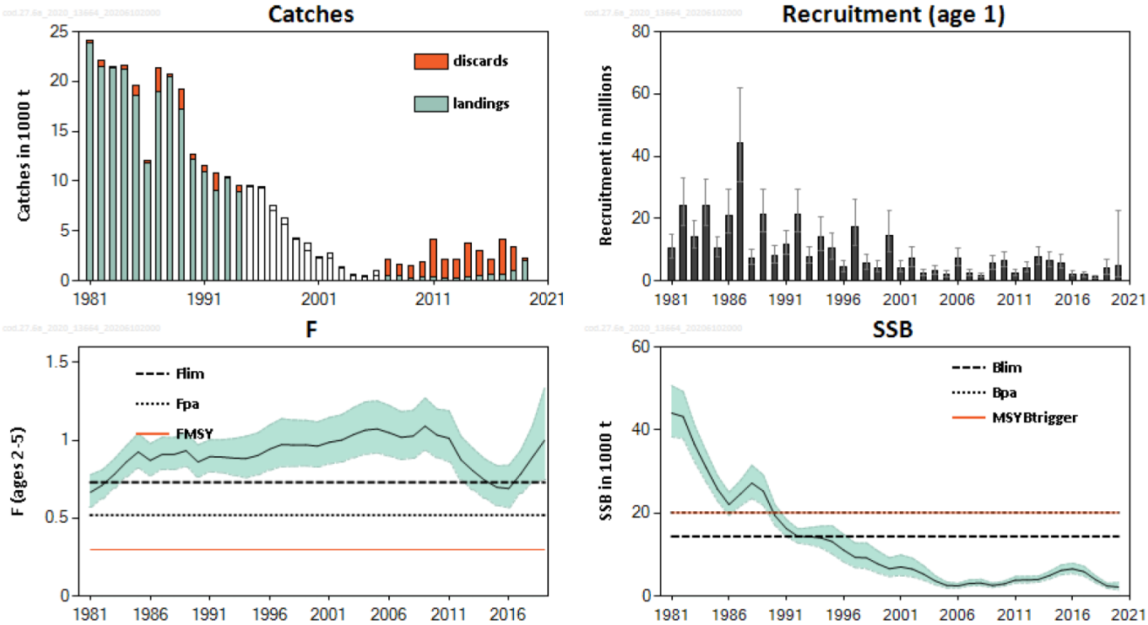

Figure 20: Cod 6a. Summary of the stock assessment. Recruitment, F and SSB show confidence intervals (95%) in the plot. Figure taken from ICES 2020k.

The current spawning-stock biomass (SSB) is extremely low and has been below Blim since 1993. Recruitment (R) has also been very low since 2001. Fishing mortality (F) has been estimated above Flim since 1982, apart from the years 2015 and 2016 (ICES, 2020).

Timelines

For the West of Scotland cod stock, the timelines of the technical measures and other changes that could have potentially affected the selectivity of this stock are as follows:

- 2002—Requirement to increase mesh size (from 80 mm to 100 mm) and use of square mesh panels (90 mm).
- 2004—Introduction of the first cod effort management plan, which linked the use of selective gears to increased effort allocations. Limited uptake.
- 2006—SSB fell to very low levels (only began to increase after 2011).
- 2008—First introduction of Conservation Credit Scheme in the United Kingdom (UK) (real-time closures—RTCs) which reduced effort in areas of high concentrations of juveniles. Uptake limited to a small number of Scottish vessels.
- 2009—Introduction of the second cod effort management plan which incentivized the use of selective gears in return for increased effort allocations or removal from the effort regime altogether.

- 2009 —Introduction of emergency technical measures. Mesh size increased to 120 mm with 120 mm square mesh panels in bottom trawl (TR)1 fisheries (i.e., towed gears with a codend mesh size of greater or equal to 100 mm) and 80 mm plus 120 mm square mesh panels or sorting grid in TR2 fisheries (i.e., towed gears with a codend mesh size in the range of 79–99 mm).
- 2019 – Cod included under the Landing Obligation
- 2019 – EU MAP (2019/472) introduced for WW. Article 8 of WWMAP requires remedial measures to be taken where scientific advice indicates that the spawning stock biomass of cod is below the Blim, to ensure rapid return of the stock to levels above the level capable of producing MSY.
- 2020 -Technical measures framework Regulation (1241/2019) adopted. Phased in mesh size changes to 120mm by August 2021
- 2020 – EU sets TAC of 1279 tonnes exclusively for by-catches of cod in fisheries for other species. No directed fisheries for cod permitted in line with WWMAP.
- 2020 - New technical measures introduced for West of Scotland Nephrops fishery to protect whiting and haddock under Regulation (EU) 2239/2020. Mandatory use of 300mm smp for vessels using a codend mesh size less than 100mm (200mm for vessels less than 200Kw). Mandatory use of a square mesh panel (positioning retained) of at least 160 mm for vessels deploying a cod-end mesh size of 100-119 mm. Little impact on cod stocks anticipated.

Selectivity Indicator

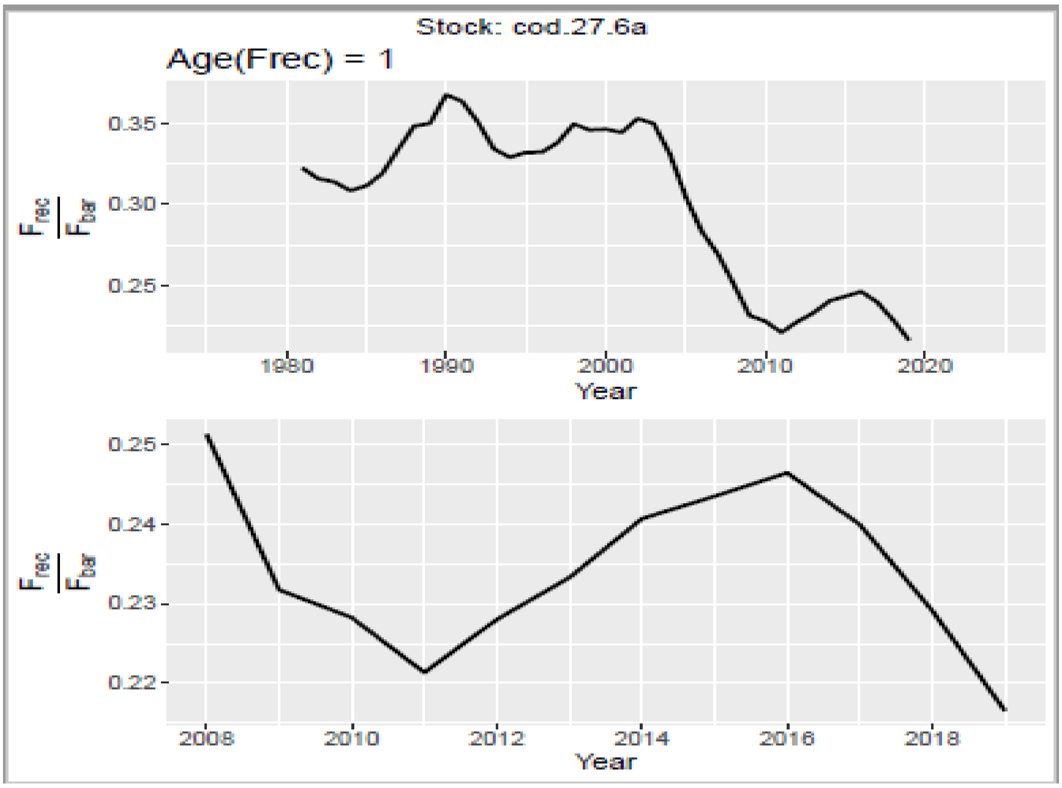

Figure 21: Cod 6a. Time-series of Selectivity indicator F_{rec}/F_{bar}. Top: full time series; Bottom: reduced time series.

Over the period 1980 to 2003, the indicator shows quite poor selectivity reflecting high catches from directed cod fisheries. Since the early 2000s, the stock has declined significantly with a period of very low recruitment and cod only caught as a bycatch in mixed demersal fisheries. The indicator shows an improvement in selectivity in the period 2002-2011 and while this corresponds to two increases in mesh size (2002 and 2009), it is unlikely these changes are the main reason for the indicated improvement in selectivity. This more likely reflects a reduction in effort and the lack of a directed fishery. After 2011 the indicator shows a gradual deterioration in selectivity up to 2016. There is no obvious reason for this that can be attributed to technical measures as during this period no major changes were made to the Regulations Since 2019 there has been a marked improvement in selectivity but again there is no clear reason for this that can be linked to changes in technical measures and cod catches were not subject to the Landing Obligation until 2019 so it cannot be linked to the Landing Obligation. It may simply reflect changes in fishing pattern.

Achievement of objective and targets (Article 3 and 4)

From 2002 onwards, the indicator suggests a trend of improving selectivity with less fishing pressure on juvenile cod and an improved exploitation pattern. However, EWG 20-02 cannot identify whether this is related to changes in technical measures or reflects changes in fishing patterns and the low level of the cod stock over a protracted period.

Whiting 6a

General stock trends

The following stock summary is taken from ICES advice (ICES 2020a).

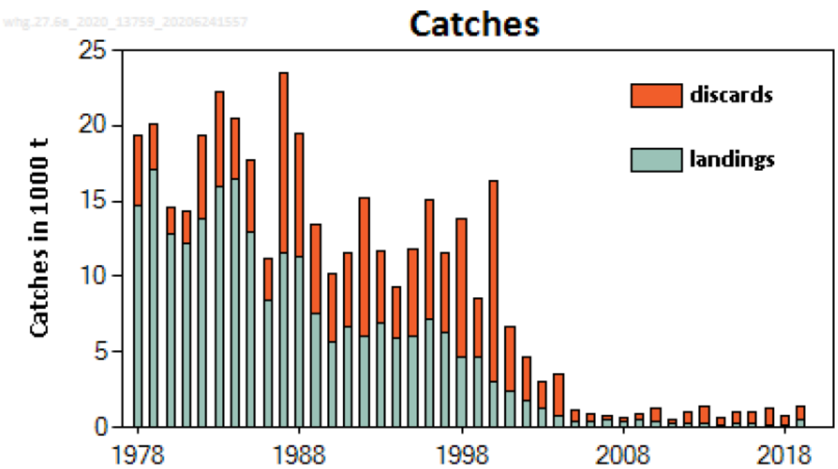

Figure 22: Whiting 6a. Summary of the stock assessment - catches. Figure taken from ICES 2020i.

The spawning–stock biomass (SSB) has been increasing since 2010 but remains very low compared to the historical estimates and is below Blim. Fishing mortality (F) has declined continuously since around 2000 and is estimated well below FMSY. Recruitment is estimated to have been very low since 2002 but estimated to have increased in recent years. Catches have progressively declined until 2005 and have remained low since then.

Timelines

For the West of Scotland whiting stock, the timelines of the technical measures and other changes that could have potentially affected the selectivity of this stock are as follows:

- 2002—Requirement to increase mesh size (from 80 mm to 100 mm) and use of square mesh panels (90 mm).
- 2004—Introduction of the first cod effort management plan, which linked the use of selective gears to increased effort allocations. Limited uptake.
- 2006—SSB fell to very low levels (only began to increase after 2011).
- 2009—Introduction of the second cod effort management plan which incentivized the use of selective gears in return for increased effort allocations or removal from the effort regime altogether.
- 2009—Introduction of emergency technical measures. Mesh size increased to 120 mm with 120 mm square mesh panels in bottom trawl (TR)1 fisheries (i.e., towed gears with a codend mesh size of greater or equal to 100 mm) and 80 mm plus 120 mm square mesh panels or sorting grid in TR2 fisheries (i.e., towed gears with a codend mesh size in the range of 79–99 mm).
- 2010 onwards— Majority of catches in TR2 fisheries but mostly discarded (undersized). Catches in TR1 fisheries were significantly reduced following the latest mesh size increases.
- 2019 – Whiting included under the Landing Obligation
- 2019 – EU MAP (2019/472) introduced for WW. Article 8 of WWMAP requires remedial measures to be taken where scientific advice indicates that the spawning stock biomass of whiting is below the Blim, to ensure rapid return of the stock to levels above the level capable of producing MSY. No remedial measures specified.
- 2020 -Technical measures framework Regulation (1241/2019) adopted. Phased in mesh size changes to 120mm by August 2021
- 2020 – EU sets TAC of 937 tonnes exclusively for by-catches of whiting in fisheries for other species. No directed fisheries for whiting permitted in line with WWMAP
- 2020 - New technical measures introduced for West of Scotland *Nephrops* fishery to protect whiting and haddock under Regulation (EU) 2239/2020. Mandatory use of 300mm smp for vessels using a codend mesh size less than 100mm (200mm for vessels less than 200Kw). Mandatory use of a square mesh panel (positioning retained) of at least 160 mm for vessels deploying a cod-end mesh size of 100-119 mm.

Selectivity indicator

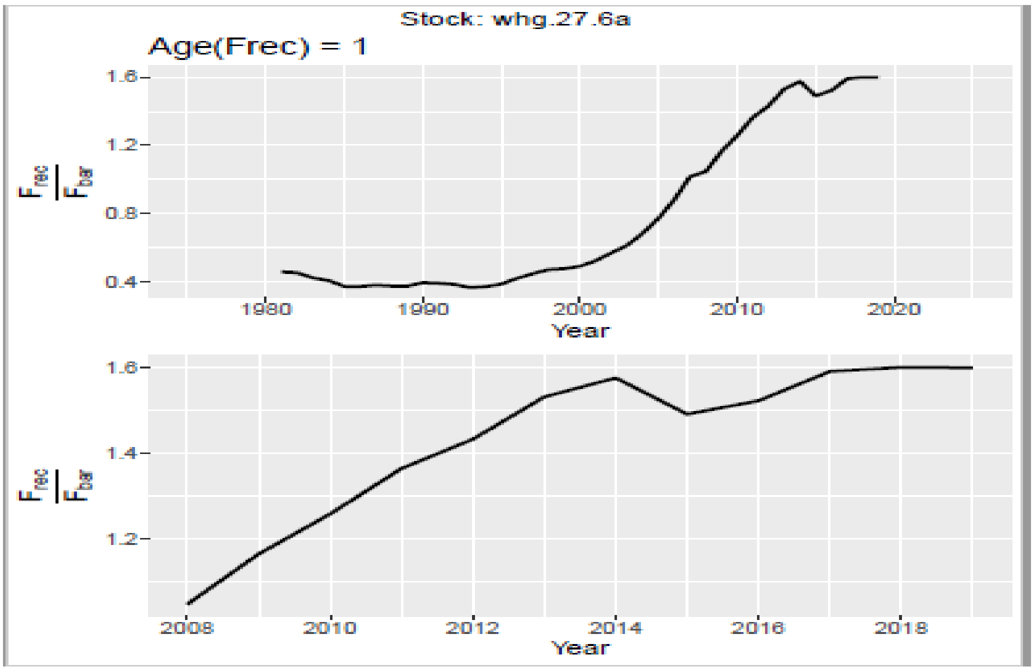

Figure 23: Whiting 6a. Time-series of Selectivity indicator F_{rec}/F_{bar}. Top: full time series; Bottom: reduced time series.

The shape of the selectivity curve in this stock was asymptotic, with the highest selection (i.e., highest F) occurring at age 4–6, apart from the last five years of the time series when selection peaked at age 1 (Figure 23). West of Scotland whiting went through a period of very low SSB and recruitment in the early 2000s. From 1995 onwards, a slow deteriorating trend in selectivity (i.e., higher targeting of juveniles) was captured by the indicator, which was further accelerated from the early 2000s onwards, when the SSB was depleted. This was because technical measures taken from 2002 onwards aimed to reduce the catch of whiting by the TR1 fisheries (gadoid fisheries), which targets adult whiting. As a result, Fbar gradually decreased. However, there was little change in the bycatch of juvenile whiting by the TR2 fishery (small mesh fishery for *Nephrops*). This led to a perception of deteriorating selectivity picked up by the indicator and is confirmed by the partial Fs, which show an increase in F in the *Nephrops* fishery and a decline in F in the other trawl fisheries for demersal species.

Achievement of objective and targets (Article 3 and 4)

Since 2008, the indicator shows a steady deterioration in juveniles which corresponds to significantly reduced fishing effort and catches in the gadoid fisheries for whiting (with more selective gears) and increase catches and effort in the small mesh, less selective *Nephrops* fishery. In this fishery unwanted catches of small whiting have continued at high levels for many years without any improvement in gear selectivity. For this stock it is apparent that the objective in Article 3 is not being met and the exploitation pattern in the *Nephrops* fishery is sub-optimal.

Haddock 6a

General stock trends

The following stock summary is taken from ICES advice (ICES 2020a).

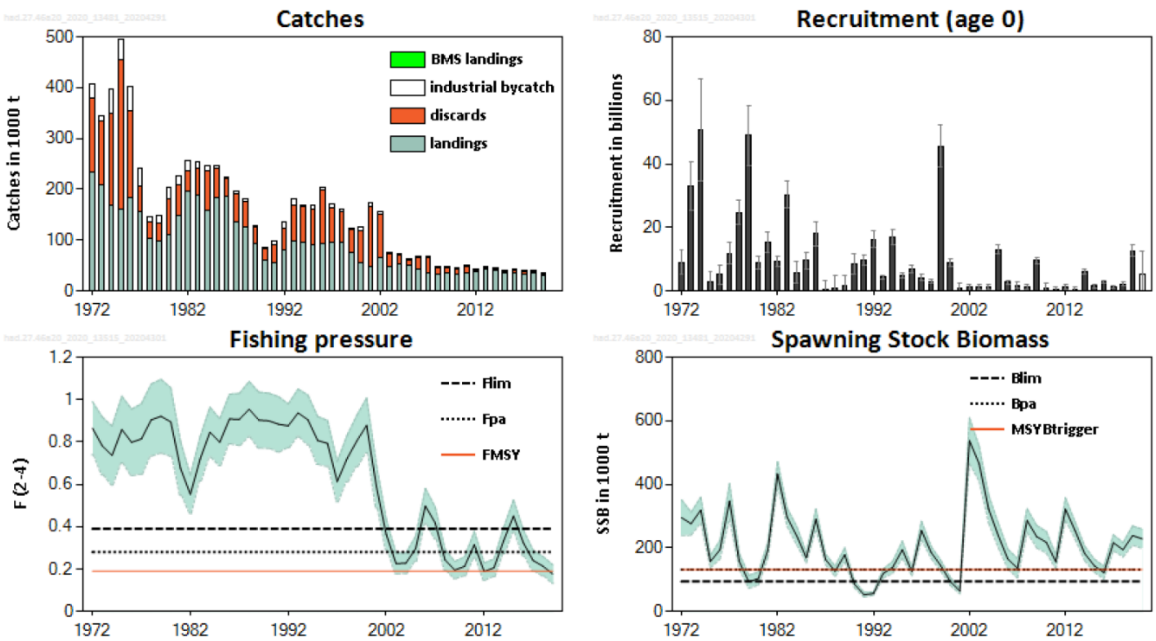

Figure 24: Haddock 6a. Summary of the stock assessment. Recruitment, F and SSB show confidence intervals (95%) in the plot. Figure taken from ICES 2020a.

West of Scotland haddock is considered by ICES to be part of the North Sea haddock stock and ICES has provided advice for the whole stock since 1995. Fishing mortality (F) has declined since the beginning of the 2000s, but it has been above FMSY for the entire time-series. Spawning-stock biomass (SSB) has been above MSY Btrigger in most of the years since 2002. Recruitment since 2000 has been low with occasional larger year classes. The 2019-year class is estimated to be the largest since 2000.

Timelines

For the West of Scotland haddock stock, the timelines of the technical measures and other changes that could have potentially affected the selectivity of this stock are as follows:

- 1983—First EU Technical Measures Regulation established minimum mesh sizes and restrictions on the construction and use of trawl gears. As part of this regulation the mesh size increased from 80 mm in 1983 to 90 mm in 1984.
- 1986—Revised Technical Measures Regulation increased mesh size for gadoid fisheries.
- 2002—Mesh size increased to 100 mm for West of Scotland demersal fisheries with requirement to use 90mm SMP. Restrictions on gear construction and specific measures for certain fisheries (beam trawls and gillnets) introduced.
- 2004—Introduction of first cod effort management plan, which included a provision to allow increased fishing effort when using selective gears. Limited uptake.
- 2008—First introduction of Conservation Credit Scheme in the United Kingdom (UK) (real-time closures—RTCs) which reduced effort in areas of high concentrations of juveniles. Uptake limited to a small number of Scottish vessels.
- 2009—Introduction of second cod effort management plan which further incentivized the use of selective gears in return for increased effort allocations. Increased uptake particularly in the UK as part of the Conservation Credit Scheme
- 2009—Revised Conservation Credit Scheme in the UK (RTCs). The use of more selective gears was made mandatory for UK vessels in certain fisheries with haddock bycatch.
- 2009—Introduction of emergency technical measures. Mesh size increased to 120 mm with 120 mm square mesh panels in bottom trawl (TR)1 fisheries (i.e., towed gears with a codend mesh size of greater or equal to 100 mm) and 80 mm plus 120 mm square mesh panels or sorting grid in TR2 fisheries (i.e., towed gears with a codend mesh size in the range of 79–99 mm).
- 2018 - All catches of haddock subject to the Landing Obligation where total landings per vessel of all species consisted of more than 5 % of cod, haddock, whiting and saithe combined
- 2019 – All catches of haddock subject to the Landing Obligation.
- 2019 – EU MAP (2019/472) introduced for WW.
- 2020 -Technical measures framework Regulation (1241/2019) adopted. Phased in mesh size changes to 120mm by August 2021
- 2020 - New technical measures introduced for West of Scotland *Nephrops* fishery to protect haddock and whiting under Regulation (EU) 2239/2020. Mandatory use of 300mm smp for vessels using a codend mesh size less than 100mm (200mm for vessels less than 200Kw). Mandatory use of a square mesh panel (positioning retained) of at least 160 mm for vessels deploying a cod-end mesh size of 100-119 mm.

Selectivity indicators

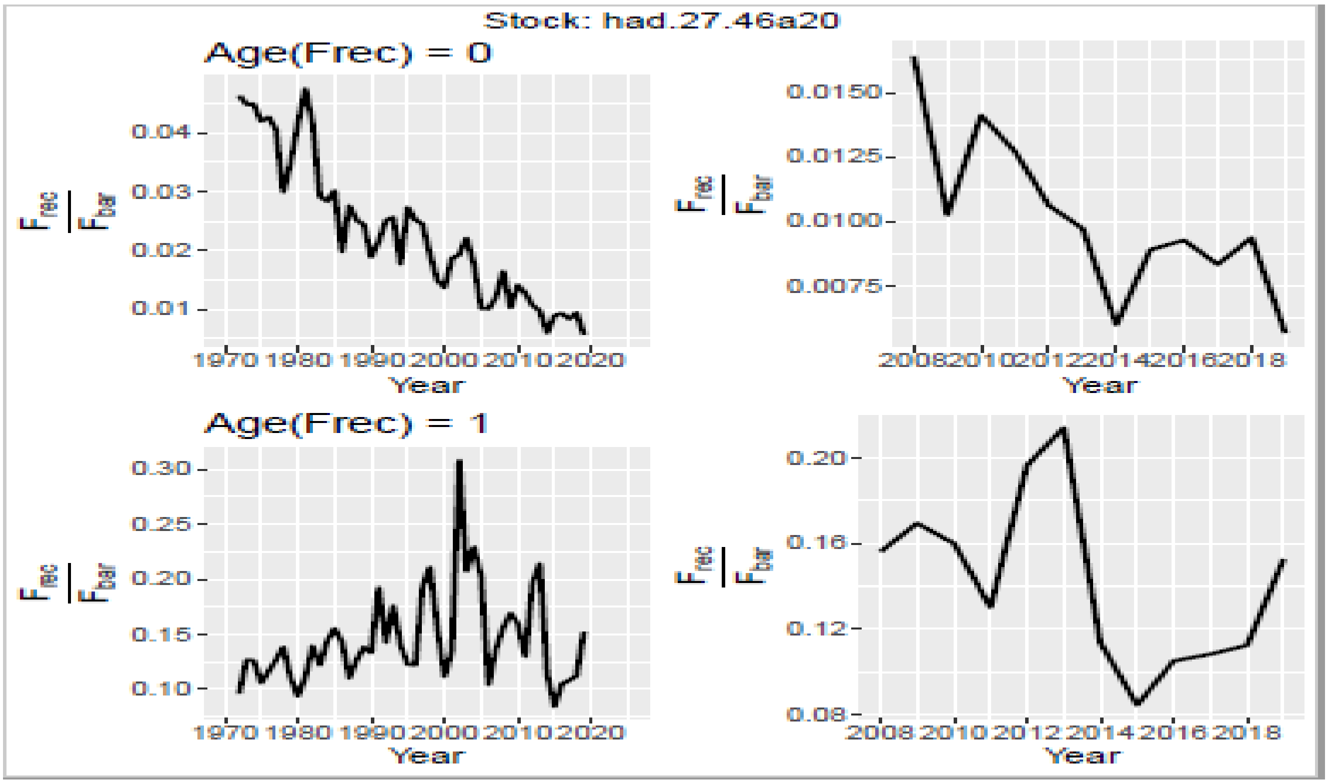

Figure 25: Haddock 6a. Time-series of Selectivity indicator F_{rec}/F_{bar}. Top (Frec = 0) left: full time series; Top right: reduced time series ; Bottom (Frec = 1) left: full time series; Bottom right: reduced time series.

West of Scotland haddock is considered a small component part of the North Sea haddock and therefore it is not possible to conclude on the trends in selectivity solely for the West of Scotland component of the stock. The stock has a history of strong recruitment pulses and a big Fbar reduction after 2000. Catches in 6a have been relatively stable since 2013 and based on IOCES assessments, discards have reduced.

Taking Age(Frec) at zero, the selectivity indicator has a relatively smooth decreasing trend (Figure 25). This trend indicates an improving selectivity, which broadly agrees with the relevant consecutive technical measures implemented from 1980 onwards but largely in the North Sea and only in the West of Scotland from 2002 onwards.

Catches of zero age group haddock is very low and on therefore the indicator has also been plotted with Age (Frec) as 1. The indicator shows a gradual deterioration in selectivity up to about 2002 and then a gradual improvement up to about 2015. Recruitment in the stock has been low in this period. From 2015 onwards, the trend shows a decline in selectivity corresponding to the repealing of the cod recovery plan that limited fishing effort. This is the converse of the indications for West of Scotland and North Sea cod. There is no clear indication that technical measures are responsible in the changes of the trends from the indicator or that the Landing Obligation has had any impact on the stock.

Achievement of objective and targets (Article 3 and 4)

As west of Scotland haddock is assessed as part of the North Sea, it is not possible to conclude whether the objectives in Article 3 has been met or not, as no data has been provided to allow deriving an indicator specific to West of Scotland haddock. The selectivity indicator is highly variable from year-to -year from 2008 onwards. There is an improving trend in selectivity over the period 2009- 2015, except for 2011 and 2012 when the indicator shows the opposite trend. After 2015, the indicator has shown a deterioration in selectivity. It is unclear whether the Article 3 objective has been met or not, nor is it clear whether technical measures have been effective or not.

Saithe 6a

General stock trends

The following stock summary is taken from ICES advice (ICES 2020a).

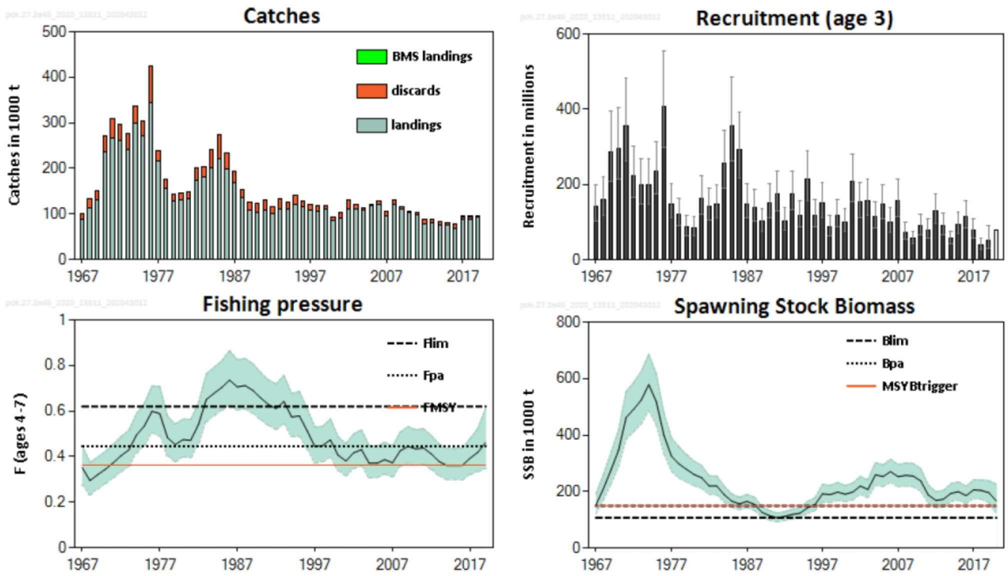

Figure 26: Saithe 6a. Summary of the stock assessment. Recruitment, F and SSB show confidence intervals (95%) in the plot. Figure taken from ICES 2020e.

West of Scotland saithe is considered by ICES to be part of the North Sea haddock stock and is assessed accordingly. Spawning-stock biomass (SSB) has fluctuated without trend and has been above MSY Btrigger since 1996. Fishing mortality (F)has decreased and stabilized at or below FMSY since 2014. Recruitment (R) has shown an overall decreasing trend overtime with lowest levels in the past 10 years.

Timelines

For the West of Scotland saithe stock, the timelines of the technical measures and other changes that could have potentially affected the selectivity of this stock are as follows:

- 1983—First EU Technical Measures Regulation established minimum mesh sizes and restrictions on the construction and use of trawl gears. As part of this regulation the mesh size increased from 80 mm in 1983 to 90 mm in 1984.
- 1986—Revised Technical Measures Regulation increased mesh size for gadoid fisheries.
- 2002—Mesh size increased to 110 mm for West of Scotland and North Sea gadoid fisheries. Catches with mesh sizes in the range of 110 to 119 mm containing at least 70 % of saithe subject to a bycatch limit of no more than 3 % of cod. No SMP required.

- 2004—Introduction of first cod effort management plan, which included a provision to allow increased fishing effort when using selective gears. Limited uptake.
- 2008—First introduction of Conservation Credit Scheme in the United Kingdom (UK) (real-time closures—RTCs) which reduced effort in areas of high concentrations of juveniles. Uptake limited to a small number of Scottish vessels.
- 2009—Introduction of second cod effort management plan which further incentivized the use of selective gears in return for increased effort allocations. Increased uptake particularly in the UK as part of the Conservation Credit Scheme
- 2009—Revised Conservation Credit Scheme in the UK (RTCs). The use of more selective gears was made mandatory for UK vessels in certain fisheries with haddock bycatch.
- 2009—Introduction of emergency technical measures. Mesh size increased to 120 mm with 120 mm square mesh panels in bottom trawl (TR)1 fisheries (i.e., towed gears with a codend mesh size of greater or equal to 100 mm) and 80 mm plus 120 mm square mesh panels or sorting grid in TR2 fisheries (i.e., towed gears with a codend mesh size in the range of 79–99 mm). Gillnetting for gadoids prohibited. Measures only applied in area inside the continental shelf and saithe fisheries largely unaffected. Vessels continued to fish with mesh size of 1
- 2018 - All catches of saithe where the total landings per vessel consisted of more than 50 % of saithe are subject to the Landing Obligation.
- 2019 – All catches of saithe subject to the Landing Obligation.
- 2019 – EU MAP (2019/472) introduced for WW.
- 2020 -Technical measures framework Regulation (1241/2019) adopted. Phased in mesh size changes to 120mm by August 2021.

Selectivity indicator

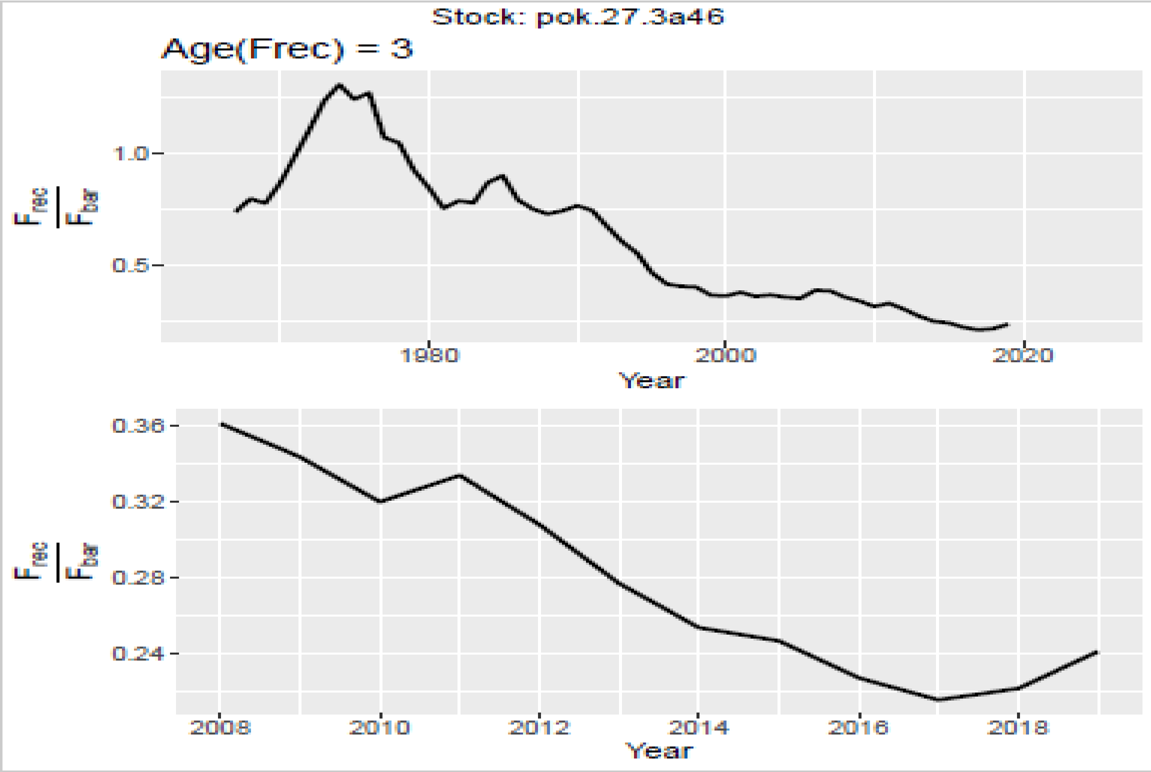

Figure 27: Saithe 6a. Time-series of Selectivity indicator F_{rec}/F_{bar}. Top: full time series; Bottom: reduced time series.

As with West of Scotland haddock, saithe in area 6 is a component of the wider North Sea saithe stock. Over the entire time series, the trend since 1980 has been a gradual improvement in selectivity and in the West of Scotland, this corresponds to a period of quite stable catches and relatively stable levels of fishing effort in the trawl fishery, which accounts for most saithe catches. The improving trend in selectivity in this case is unlikely to have any linkage to changes in technical measures. As with other stocks in the West of Scotland there is no evidence that the Landing Obligation has led to any improvements in selectivity in the main fisheries with catches of saithe.

Achievement of objective and targets (Article 3 and 4)

The indicator shows improving selectivity from 2008 onwards and would suggest the objective in Article 3 has been met. However, given the limited changes to the technical measures directly impacting of saithe, it is unlikely the improvement in selectivity observed is related to gear-based measures.

Rockall

For area 6b, Rockall haddock was the only stock for which data was available.

The timelines associated with these stocks is shown in Table 7.

Table 7: Changes of technical measures, applied to Rockall fisheries – selection of relevant measures for the period 1983 to 2019

Sea basin	Technical measure	Month	Year	Measure	Species of interest	Pros/Cons	EU reg no
Rockall	Species and size selectivity		1983	First EU technical measures regulation establishes minimum mesh of 80mm for gadoid fisheries. Increased to 90mm in 1984	Haddock	Unknow but likely to be ineffective in reducing discarding of haddock	171/1983
Rockall	Closed or restricted areas		2001	Rockall haddock box established in NEAFC Area extended into EU waters in 2002	Haddock	Limited monitoring but felet to be somewhat effective	1298/2000
Rockall	Species and size selectivity	Jan	2002	Increase mesh size from 80 mm to 100 mm and use of 90mm square mesh panels	Haddock	Improvement in selectivity for haddock	2056/2001
Rockall	Small mesh fishery		2004	Russioan fishery for juvenile haddock and gunards peaked in 2004 (catches of more than 5000 tonnes of haddock)	Haddock	Juvenile fishery. Under reporting suspected	
Rockall	Small mesh fishery		2009	Russian fishery reduced to catches of less than 5 tonnes	Haddock	Reduction in fishing effort	
Rockall	Species and size selectivity		2014	UK introduces national legislation to increase the mesh size to 120mm	Haddock	Increase in selectivity	UK national legislation
Rockall	Species and size selectivity		2019	New technical measures Regulation introduces a minimum mesh size for gadoid fisheries of 120mm to be phased in by August 2021 for the whole of area 6	Haddock	Unknown	1241/2019
Rockall	Landing Obligation	Jan	2019	All catches of haddock subject to the Landing Obligation	Haddock	Dependent on implementation	45/2018

Rockall haddock

General stock trends

The following stock summary is taken from ICES advice (ICES 2020a).

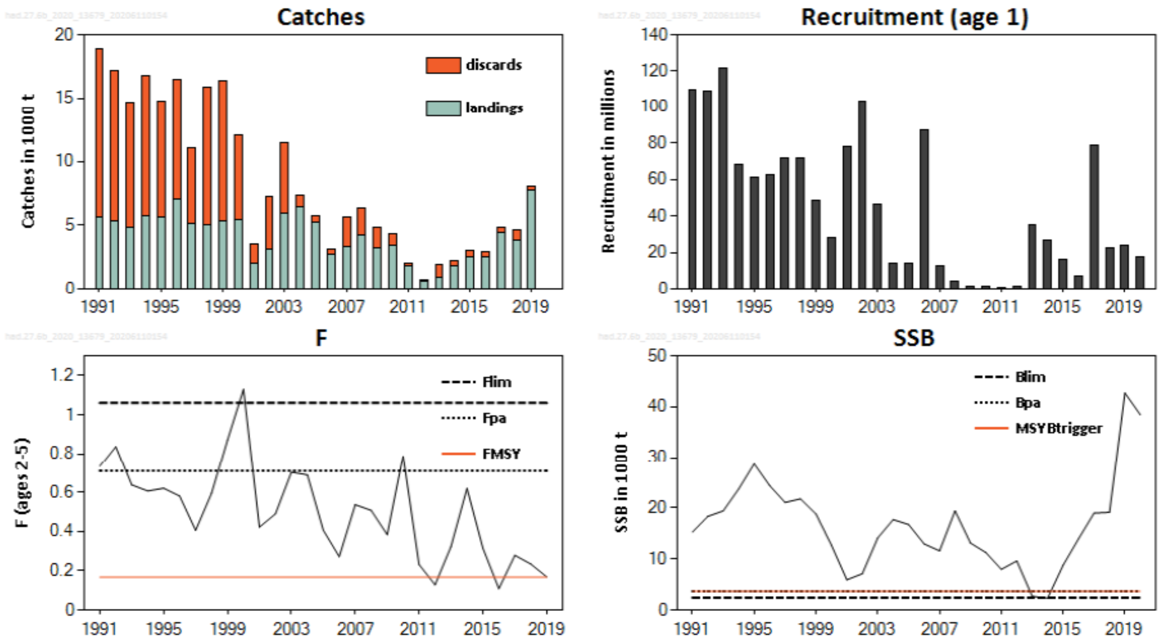

Figure 28: Rockall haddock. Summary of the stock assessment. Figure taken from ICES 2020c.

The spawning–stock biomass (SSB) has increased from the lowest estimated values in 2014 and is currently estimated to be well above MSY Btrigger. Fishing mortality (F) has been declining and is below FMSY in 2018. Recruitment during 2008–2012 is estimated to have been extremely weak but has improved since then. Recruitment in 2018 and 2019 is estimated to be below average.

Timelines

For the Rockall haddock stock, the timelines of the technical measures and other changes that could have potentially affected the selectivity of this stock are as follows:

- 1983—First EU Technical Measures Regulation established minimum mesh sizes and restrictions on the construction and use of trawl gears. As part of this regulation the mesh size increased from 80 mm in 1983 to 90 mm in 1984.
- 1986—Revised Technical Measures Regulation increased mesh size for gadoid fisheries.
- 2001 – Rockall haddock box established in 2001 in the NEAFC area
- 2002- Rockall haddock box extended into EU waters
- 2002—Mesh size increased to 100 mm including Rockall demersal fisheries with requirement to use 90mm SMP.
- 2004 – Russian fishery (1999-2008) for juvenile haddock in international waters in 6b. Fishery peaked in 2004 (more than 5000 tonnes). Considerable concerns of under reporting.
- 2009 – Russian fishery reduced to very low levels (to less than 5 tonnes)
- 2008 -2012 – Period of very low recruitment. Fishery at low level.
- 2013 – ICES advise zero catch. SSB at lowest recorded level.
- 2014 – UK introduces national legislation increasing the mesh size to 120mm

- 2018 -2019 – Significant recruitment pulses and SSB increases Selectivity indicators

Selectivity indicators

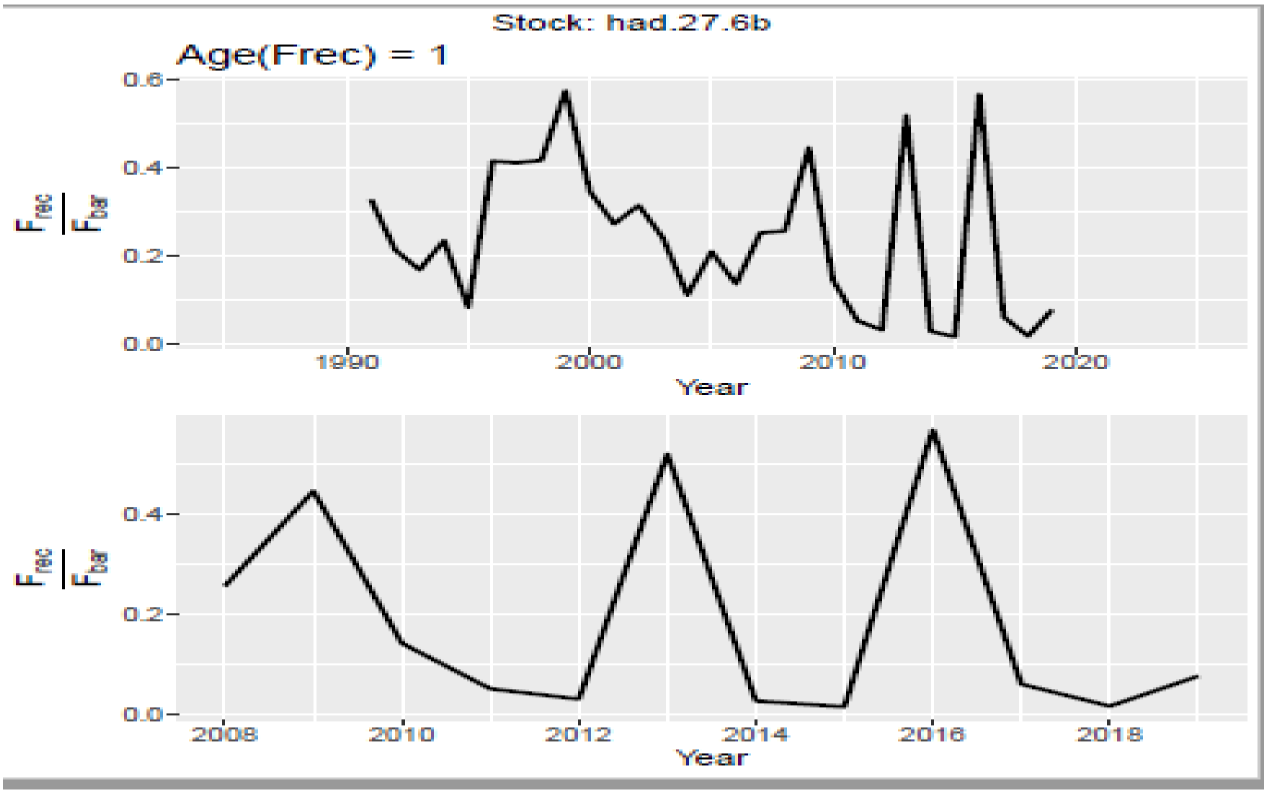

Figure 29: Haddock 27.6b. Time-series of Selectivity indicator F_{rec}/F_{bar}. Top: full time series; Bottom: reduced time series.

Over the entire time series, there have been relatively few changes in technical measures of any consequence, other than the introduction of the haddock Box in 2001/2002. Corresponding to the introduction of this closed area, which had the objective of protecting juvenile haddock, there is an improvement in selectivity, but this is followed by a reduction between 2005-2009. From 2009 to 2011 the indicator shows an improvement in selectivity this corresponds to a period of very low recruitment in the fishery and the decline of the Russian fishery for juvenile haddock. From 2011, the selectivity pattern has been relatively stable apart from two peaks in 2013 and again in 2016. These two peaks correspond to large jumps in fishing effort by the Irish otter trawl fleet in these years.

Achievement of objective and targets (Article 3 and 4)

Generally, since 2008 the selectivity indicator shows selectivity has improved and stabilized. However, in 2013 and 2016 there are spikes in the indicator that are linked to spikes in the partial F's for bottom trawls. Given the overall trend is positive it would seem the objective of reducing catches if juveniles have been achieved. However, as with other stocks it is not possible to link this specifically to changes in technical measures.

Stocks of Irish and Celtic Seas

This study focuses on four Irish Sea stocks; cod, haddock, whiting and plaice. Data for the calculation of the chosen selectivity indicator were available for haddock, whiting and plaice, but not for cod. The main relevant changes in technical measures are listed in Table 8.

In the Celtic Sea, the study considers only two stocks, megrim, and plaice in 7e. It would have been valuable to look at other species, particularly cod, haddock and whiting, however no data were made available to generate the selectivity indicators for these species.

Table 8: Changes of technical measures, applied to Irish Sea fisheries – selection of relevant measures for the period 2009 to 2019

Sea basin	Technical measure	Year	Measure	Species of interest	Pros/Cons	EU reg no
Irish Sea	Effort restriction	2009	Maximum allowable effort allocation 2nd cod recovery programme	Cod	didn't seem to make any improvement	1342/2008
Irish Sea	Species and size selectivity	2010	Irish & UK vessels use Swedish grid for Nephrops fishery with almost zero cod catches	Cod, haddock, whiting	Not sure how many vessels took this up c. 10?	1342/2008
Irish Sea	Species and size selectivity	2018	Cod recovery plan 2016. UK vessels with range of gear changes	Cod, haddock, whiting		2016/2094 ??
Irish Sea	Multi Annual Plan	2018	Cod plan is replaced by WW MAP	Cod, haddock, whiting	Unkown impact	472/2019
Irish Sea	Multi Annual Plan	2018	Whiting & Cod TAC exclusively for by-catches. No directed fisheries	Cod	Unkown impact	472/2019
Irish Sea	Closed or restricted areas	2019	Irish Sea cod box modified (technical measures	Cod	Most derogations removed	2019/1241

			framework regulation)			
Irish Sea	Landing Obligation	2019		All	Low compliance	1248/2019
Irish Sea	Landing Obligation	2018	All haddock catches of haddock > 10 % of cod, haddock, whiting and saithe combined	haddock	Low compliance	1380/2013
Celtic Sea	Species and size selectivity	2012	SMP increased for TR1 (100mm) and TR2 (110mm)	haddock, whiting,megrim		
Celtic Sea	Species and size selectivity	2015	SMP increased for TR1 and TR2 (120mm)	haddock, whiting,megrim		
Celtic Sea	Species and size selectivity	2019	Baseline mesh increased to 100mm	All	derogation for vessels targeting megrim, anglerfish and hake	1248/2019
Celtic Sea	Landing Obligation	2019		All	Low compliance	1248/2019

Irish Sea cod

General stock trends

The following stock summary is taken from ICES advice (ICES 2020a).

Current assessment is type 3 – survey based assessment trends. Assessment indicates steady recovery from 2009 to 2015, followed by a steady decline to 2018. Relative fishing pressure has been very low since 2013

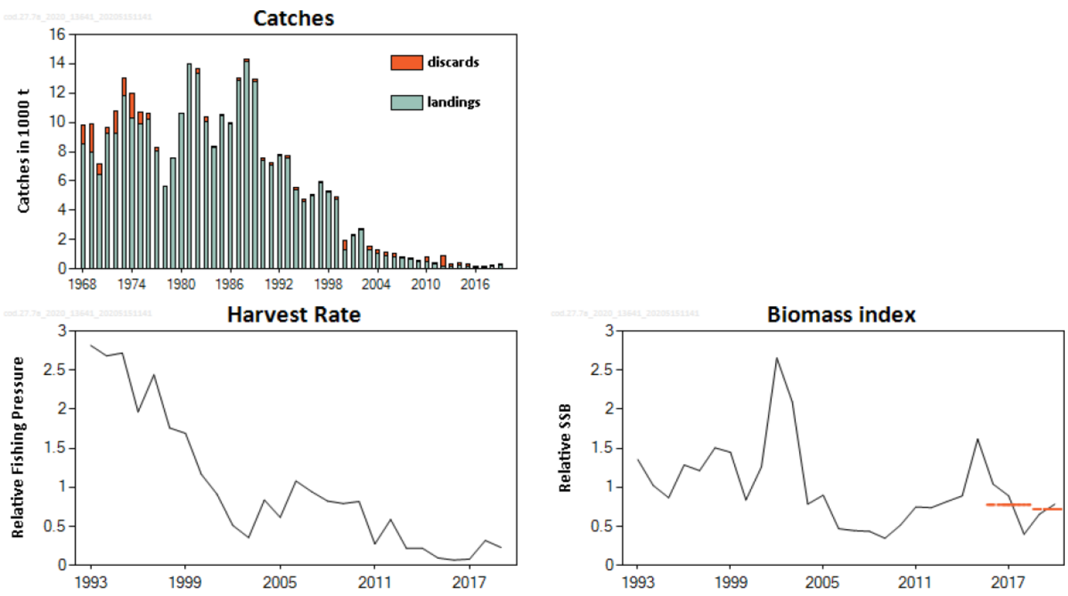

Figure 30: Irish Sea cod. Summary of the stock assessment. Figure taken from ICES 2020j.

The landing obligation was implemented in the Irish Sea from 2019.

<u>Selectivity indicator</u>

No selectivity indicator produced due to lack of a full analytical assessment and f at age data.

Management measures

Implemented measures for the recovery of cod stocks include closed seasons, areas and gears (Council Regulation (EC) No 850/98) in 1998. Further regulation (EC 1342/2008), introducing multi-annual selection of TACs, restriction of effort, technical measures, control and enforcement, structural and market measures was replaced in 2017 (EU 2094-2016) and 2018 (EU 2018/973), and amended in 2019 with the Western Waters MAP regulation ((EU) 2019/472).

Timelines

“Major” measures are highlighted in yellow

- 1999 – ICES advise Irish cod stock close to collapse.
- 2000 – Irish Sea cod box first introduced through Regulation (EC) 304/2000 as part of a cod recovery plan for the Irish Sea with derogations for the Nephrops

fishery. Additional technical measures introduced relating to gear construction (twine thickness, 80mm SMP; headline panel)

- 2001 – Derogations for specific fisheries (e.g. Nephrops and semi-pelagic haddock fishery) to operate in the closed area introduced with an observer scheme to monitor cod catches.
- 2002 – Further modifications to the closed area to prohibit the use of semi-pelagic trawls and allow the use of Nephrops trawls fitted with an inclined separator panel in a larger area. Additional technical measures applied to beam trawls with requirement to use 180mm headline panel.
- 2009—Introduction of second cod effort management plan which included the Irish Sea and further incentivized the use of selective gears in return for increased effort allocations.
- 2010-2012 – Up to xx Irish vessels use the Swedish grid in the Nephrops fishery with almost zero catches of cod under the cod recovery plan. UK vessels also begin using selective gears.
- 2012 – Cod Plan amended, and effort reductions effectively removed
- 2018 – UK makes the use of highly selective gears mandatory in the *Nephrops* fishery (7 gear options specified including 300mm SMP, Seltra box trawls, grids and separator trawls)
- 2018 onwards - Cod TAC set exclusively for by-catches of whiting in fisheries for other species. No directed fisheries for cod permitted
- 2018 – Cod plan is replaced by WW MAP
- 2019 – All catches of cod subject to the Landing Obligation
- 2019 – Irish Sea cod box modified under the technical measures framework regulation. Most derogations removed.
- 2019 – Specific technical measures introduced into the Irish Sea demersal fisheries (range of gear options for *Nephrops* and demersal stocks) under the NWW discard plan (Regulation (EU) 2239/2019

Irish Sea Haddock

General stock trends

The following stock summary is taken from ICES advice (ICES 2020a).

Current assessment is type 1 Quantitative Assessment. Assessment indicates that the stock was generally close to BSYBtrigger until around 2013, when it expanded dramatically, and remains high. F was also low from 2013 onwards and for the first time was below Fmsy.

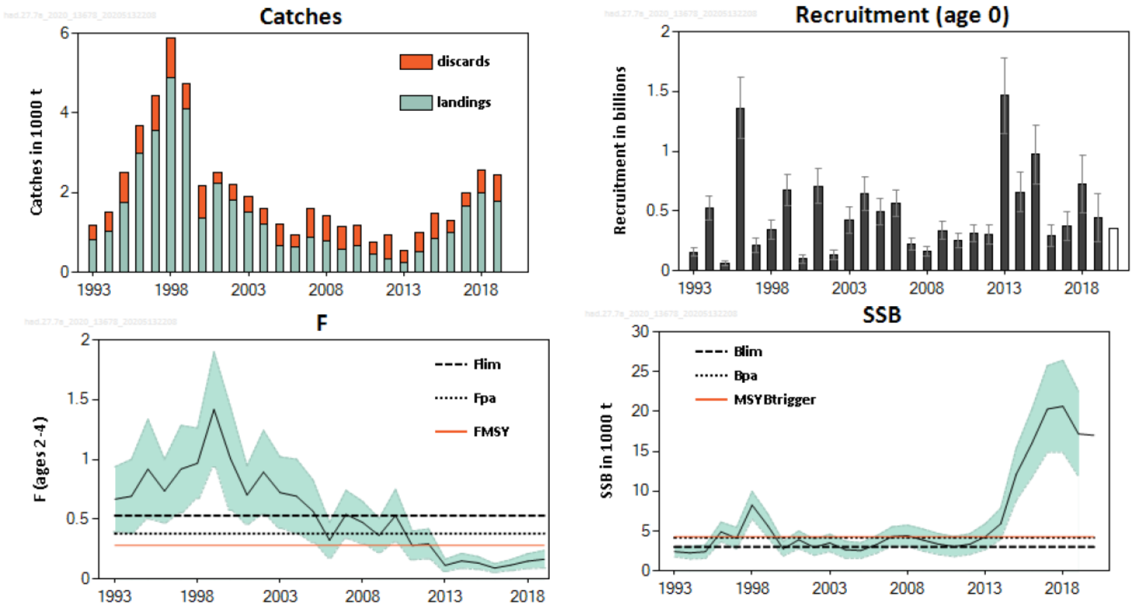

Figure 31: Irish Sea haddock. Summary of the stock assessment. Recruitment, F and SSB show confidence intervals (95%) in the plot. Figure taken from ICES 2020b.

The landing obligation was implemented in the Irish Sea from 2019.

Timelines

"Major" measures since 2010 are highlighted in yellow

- 2000 – Irish Sea cod box first introduced through Regulation (EC) 304/2000 as part of a cod recovery plan for the Irish Sea with derogations for the Nephrops fishery. Additional technical measures introduced relating to gear construction (twine thickness, 80mm SMP; headline panel)
- 2001 – Derogations for specific fisheries (e.g. Nephrops and semi-pelagic haddock fishery) to operate in the closed area introduced with an observer scheme to monitor cod catches.
- 2002 – Further modifications to the closed area to prohibit the use of semi-pelagic trawls and allow the use of Nephrops trawls fitted with an inclined separator panel in a larger area. Additional technical measures applied to beam trawls with requirement to use 180mm headline panel.
- 2009—Introduction of second cod effort management plan which included the Irish Sea and further incentivized the use of selective gears in return for increased effort allocations.

- 2010-2012 – Up to 10 Irish vessels use the Swedish grid in the Nephrops fishery with almost zero catches of cod under the cod recovery plan. UK vessels also begin using selective gears.
- 2012 – Cod Plan amended, and effort reductions effectively removed
- 2018 – UK makes the use of highly selective gears mandatory in the *Nephrops* fishery (7 gear options specified including 300mm SMP, Seltra box trawls, grids and separator trawls)
- 2018 - All catches of haddock per vessel consisting of more than 10 % of cod, haddock, whiting and saithe combined subject to the Landing Obligation
- 2018 – Cod plan is replaced by WW MAP
- 2019 – All catches of haddock subject to the Landing Obligation
- 2019 – Irish Sea cod box modified under the technical measures framework regulation. Most derogations removed.
- 2019 – Specific technical measures introduced into the Irish Sea demersal fisheries (range of gear options for *Nephrops* and demersal stocks) under the NWW discard plan (Regulation (EU) 2239/2019

Selectivity indicator

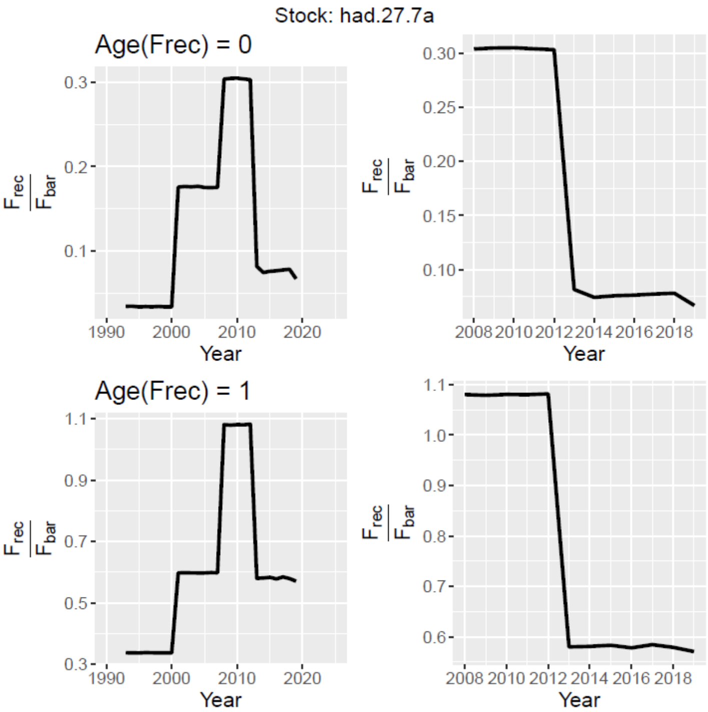

Figure 32: Irish Sea haddock. Time-series of Selectivity indicator F_{rec}/F_{bar}. Top (Frec = 0) left: full time series; Top right: reduced time series; Bottom (Frec = 1) left: full time series; Bottom right: reduced time series.

There have been several clear step changes in the selectivity over the full time period in 2000, 2007 & 2013, and these are found in both age 0 and age 1. With such abrupt changes it may be possible to link with tech measure changes. In 2000, the change was to poorer selection of the recruit year classes. In this year the Irish Sea box was introduced for cod, which may have displaced effort into juvenile areas. Other tech measures including an 80mm SMP and a headline panel were introduced that might have reduced, but are unlikely to have increased the selectivity indicator. No tech measures were introduced in 2007 that can explain a second increase in the indicator. Finally, by 2013 the Swedish grid had been introduced in some nephrops vessels, but this would be an unlikely explanation for the substantial improvements in 2013.

Given the steady state between these changes, it may well be that this is an artefact from changes in the assessment procedure.

Achievement of objective and targets (Article 3 and 4)

While it is difficult to evaluate the selectivity indicator changes across the time series, since 2010, the indicator has been low for the age 0 fish suggesting that the objective of protecting the juvenile fish has been achieved. There is no evidence of a link with changes in technical measures or management.

Irish Sea whiting

General stock trends

The following stock summary is taken from ICES advice (ICES 2020a).

Current assessment is type 1 Quantitative Assessment. The stock size is extremely low. Spawning-stock biomass (SSB) has been declining since the start of the time-series and has been well below B_{lim} since the mid-1990s. Recruitment has been low since the early 1990s. Fishing pressure (F) has declined since 2015 but remains above FMSY and Flim in 2018.

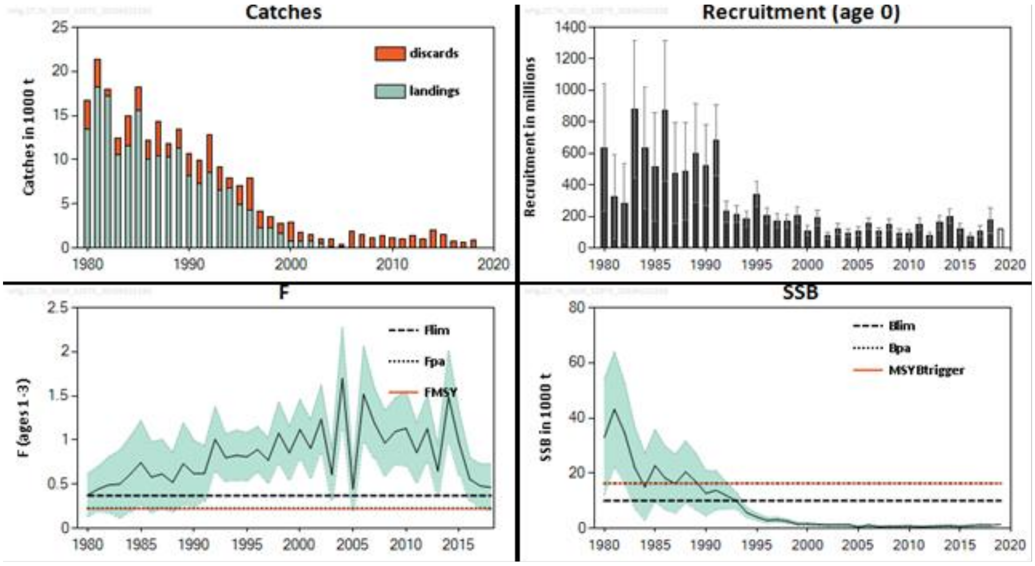

Figure 33: Irish Sea whiting. Summary of the stock assessment. Recruitment, F and SSB show confidence intervals (95%) in the plot. Figure taken from ICES 2020h.

The landing obligation was implemented in the Irish Sea from 2019.

Timelines

“Major” measures since 2010 are highlighted in yellow

- 1980s - SSB declining steadily
- 1990s – Recruitment consistently low with high Fishing Mortality throughout the 1990s
- 2000 – Irish Sea cod box first introduced through Regulation (EC) 304/2000 as part of a cod recovery plan for the Irish Sea with derogations for the Nephrops

fishery. Additional technical measures introduced relating to gear construction (twine thickness, 80mm SMP; headline panel)

- 2000 – Landings reduced by more than 50% compared to 1999
- 2001 – ICES advise zero catch for whiting stock (and have advised up to and including for 2021)
- 2001 – Derogations for specific fisheries (e.g. Nephrops and semi-pelagic haddock fishery) to operate in the closed area introduced with an observer scheme to monitor cod catches.
- 2002 – Further modifications to the closed area to prohibit the use of semi-pelagic trawls and allow the use of Nephrops trawls fitted with an inclined separator panel in a larger area. Additional technical measures applied to beam trawls with requirement to use 180mm headline panel.
- 2006 – Landings reduced to 64 tonnes but with very high discards (1770 tonnes)
- 2009—Introduction of second cod effort management plan which included the Irish Sea and further incentivized the use of selective gears in return for increased effort allocations.
- 2010-2012 – Up to 10 Irish vessels use the Swedish grid in the Nephrops fishery with almost zero catches of cod under the cod recovery plan. UK vessels also begin using selective gears.
- 2012 – Cod Plan amended, and effort reductions effectively removed
- 2015 – Large reduction in Fishing mortality reported by ICES but stock still fished above Fmsy
- 2018 – UK makes the use of highly selective gears mandatory in the *Nephrops* fishery (7 gear options specified including 300mm SMP, Seltra box trawls, grids and separator trawls)
- 2018 - All catches of haddock per vessel consisting of more than 10 % of cod, haddock, whiting and saithe combined subject to the Landing Obligation
- 2018 onwards – Whiting TAC set exclusively for by-catches of whiting in fisheries for other species. No directed fisheries for whiting permitted.
- 2018 – Cod plan is replaced by WW MAP
- 2019 – All catches of haddock subject to the Landing Obligation
- 2019 – Specific technical measures introduced into the Irish Sea demersal fisheries (range of gear options for *Nephrops* and demersal stocks) under the NWW discard plan (Regulation (EU) 2239/2019
- 2020 -Technical measures framework Regulation (1241/2019) adopted. Phased in mesh size changes to 120mm by August 2021 for Irish Sea mixed demersal fisheries.

Selectivity indicator

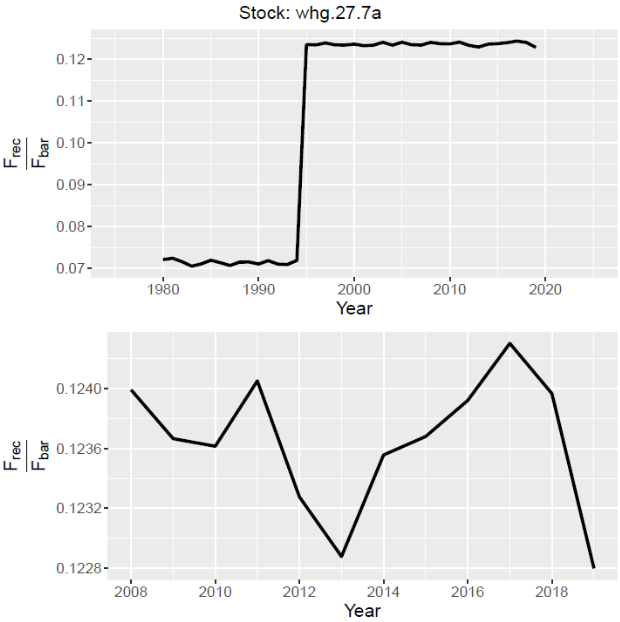

Figure 34: Irish Sea whiting. Time-series of Selectivity indicator F_{rec}/F_{bar}. Top: full time series; Bottom: reduced time series.

The indicator appears to have two different periods with a sudden step change in 1994. There is no management measure apparent that could explain this! It should be noted that both periods have relatively low values.

Achievement of objective and targets (Article 3 and 4)

The general pattern shows that the very low indicator value suggests that selectivity for young fish is good, but has not substantially changed over the last 40 years.

Irish Sea plaice

General stock trends

The following stock summary is taken from ICES advice (ICES 2020a).

Current assessment is type 1 Quantitative Assessment. In the context of the EU multiannual plan for Western Waters and adjacent waters in which this stock is considered bycatch, the EC has requested that ICES provide advice based on the precautionary approach. ICES advises that catches of up to 5,640 t are considered to be precautionary.

The stock reached its weakest SSB in the mid 1990s, and has recovered fairly steadily since, reaching MSYBtrigger in the eerily 2000s, and fluctuating around that level until 2013 when the stock expanded rapidly. Matching this, the exploitation fell to around Fmsy around 2003, and then fell well below that level from 2010.

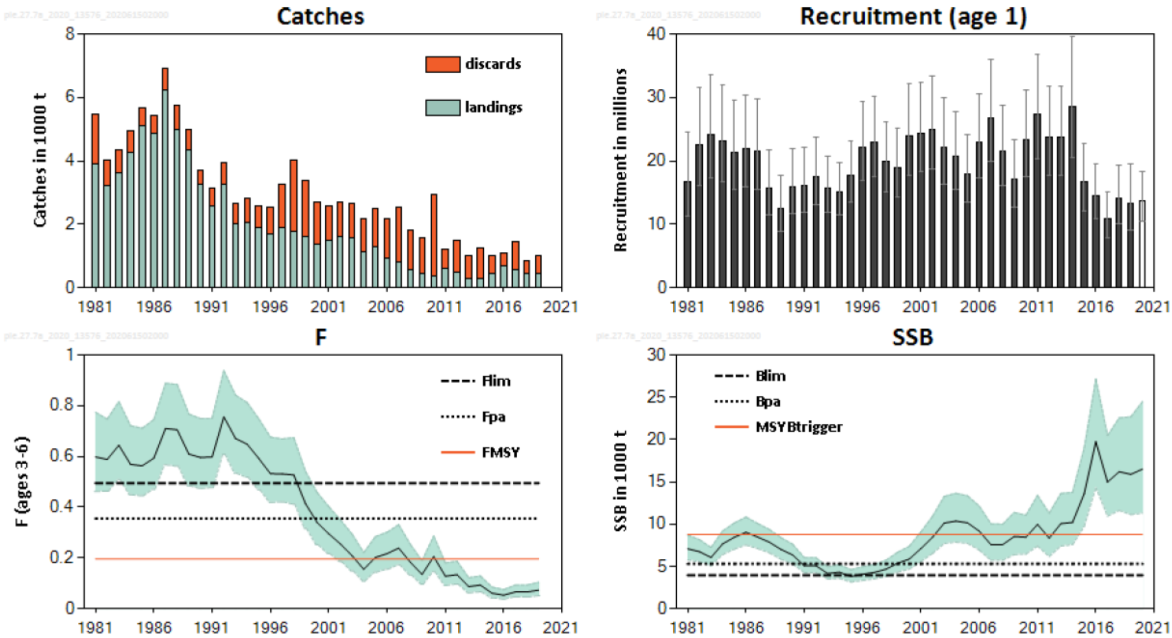

Figure 35: Irish Sea plaice. Summary of the stock assessment. Recruitment, F and SSB show confidence intervals (95%) in the plot. Figure taken from ICES 2020f.

Timelines

"Major" measures since 2010 are highlighted in yellow

- 1992 – Fishing mortality begins to decline sharply.
- 2000 – Irish Sea cod box first introduced through Regulation (EC) 304/2000 as part of a cod recovery plan for the Irish Sea with derogations for the Nephrops fishery. Additional technical measures introduced relating to gear construction (twine thickness, 80mm SMP; headline panel)
- 2001 – Derogations for specific fisheries (e.g. Nephrops and semi-pelagic haddock fishery) to operate in the closed area introduced with an observer scheme to monitor cod catches.
- 2002 – Further modifications to the closed area to prohibit the use of semi-pelagic trawls and allow the use of Nephrops trawls fitted with an inclined separator panel in a larger area. Additional technical measures applied to beam trawls with requirement to use 180mm headline panel.

- 2002 – Further modifications to the closed area to prohibit the use of semi-pelagic trawls and allow the use of Nephrops trawls fitted with an inclined separator panel in a larger area. Additional technical measures applied to beam trawls with requirement to use 180mm headline panel.
- 2004 onwards – Significant increase in discarding of plaice. Majority of catches now discarded
- 2008 -2014 – Significant decline in the SSB of sole in the Irish Sea. Plaice is a bycatch in this fishery. This resulted in significant reduction in Fishing Mortality corresponding to reduction in fishing mortality for plaice.
- 2012 onwards – Steady increase in SSB with stable but low fishing mortality
- 2019 – All catches of plaice subject to the Landing Obligation. Survival exemption for most fisheries introduced by the NWW discard plan allowing unwanted catches of plaice to be discarded.

Selectivity indicator

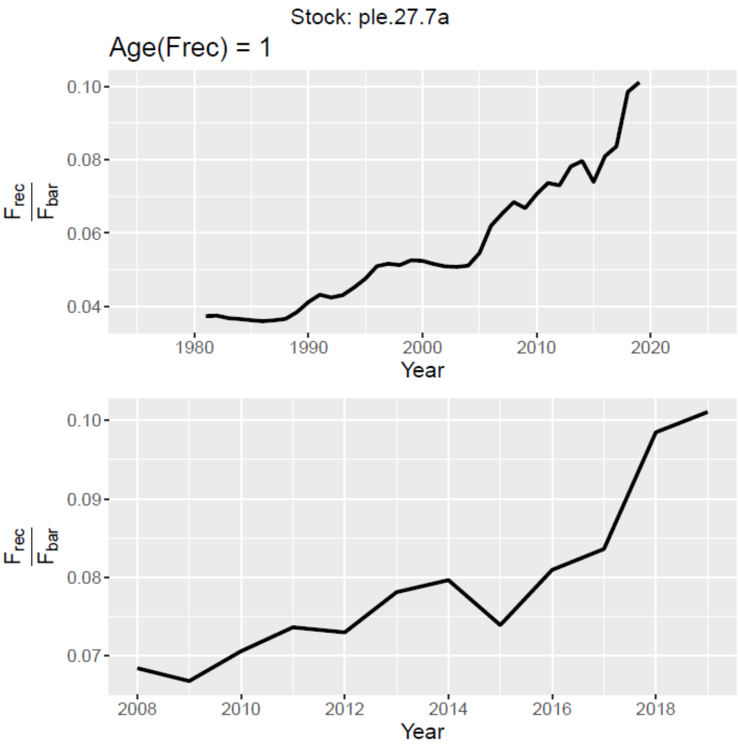

Figure 36: Irish Sea plaice. Time-series of Selectivity indicator F_{rec}/F_{bar}. Top: full time series; Bottom: reduced time series.

The indicator has been steadily increasing since 1980, and this has accelerated since around 2005, and possibly again from 2015. This means the index is getting worse, but no real "events" or breaks can be seen in the index plot. Recruitment has apparently been strong and consistent for many years, with a recent decrease. This indicator trajectory cannot be linked to any particular management measure. The main feature of this stock is that it was a bycatch in the beam trawl fishery targeting sole. Since the collapse of the sole fishery, the effort on plaice has declined.

Achievement of objective and targets (Article 3 and 4)

The level of the indicator is very low, suggesting that selectivity for young fish is good. The increase in the indicator is most likely due to the substantial increase in the stock and generally strong recruitment. No links with technical measures or management could be determined.

Celtic Sea megrim

General stock trends

The following stock summary is taken from ICES advice (ICES 2020a).

Current assessment is type 1 Quantitative Assessment. The spawning-stock biomass (SSB) has been above MSY Btrigger since 2008 and continues to increase. SSB is now at its highest point in the time series. The fishing mortality (F) has decreased since 2005, and it is below FMSY in 2018. Recruitment (R) has been relatively stable throughout the ☐me series, although the last two years are above the time series average.

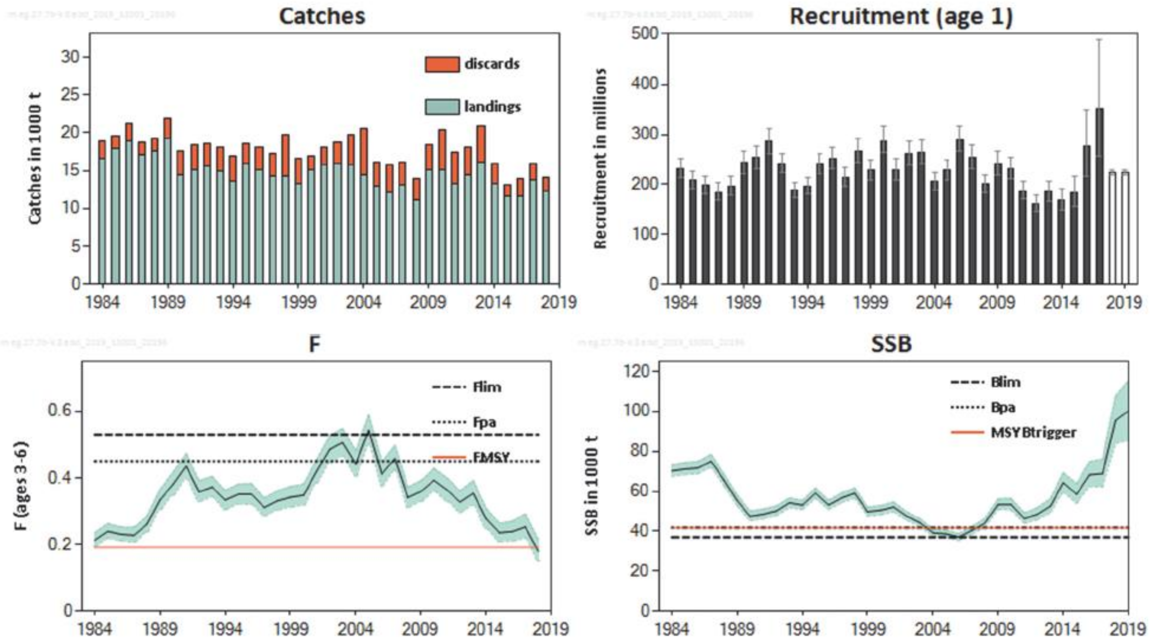

Figure 37: Celtic Sea megrim. Summary of the stock assessment. Recruitment, F and SSB show confidence intervals (95%) in the plot. Figure taken from ICES 2020d.

Timeline

“Major” measures since 2010 are highlighted in yellow

- 1998 – New technical measures Regulation introduces limited improvements in selectivity, including the use of 80mm codend mesh size in demersal fisheries in the Celtic Sea.
- 2002 – The hake recovery plan introduces increased mesh sizes in parts of the Celtic Sea. Seasonal closed areas in the Celtic Sea also introduced, primarily to protect cod but impacted on beam trawlers targeting plaice, sole and megrim.
- 2005 – Sharp decrease in Fishing mortality.
- 2008 onwards – SSB increasing steadily
- 2012 – Mesh size of square mesh panels increased in TR1 fisheries3 (100mm) and TR2 fisheries4 (110mm).
- 2015 – Regulations amended and further improvements in selectivity introduced with mesh size in square mesh panels increased to 120mm for both TR1 and TR2 fisheries with a derogation for a directed whiting fishery of 100mm+100mm smp in which haddock are an important bycatch. Regulations likely to have some impact on megrim.

- 2019 – WWMAP introduced for stocks in WW.
- 2019 – Technical measures framework regulation introduces new baseline mesh size ranges for the Celtic Sea with a general increase in mesh size to 100mm. Derogation for vessels targeting megrim, anglerfish and hake.
- 2019 – All catches of megrim subject to the Landing Obligation. De minimis exemption introduced to allow discarding of unwanted catches of megrim caught in demersal trawl fisheries.
- 2020 – Additional technical measures introduced into the Celtic Sea to protect cod and whiting stocks. Megrim catches may be impacted in some demersal trawl fisheries.

Selectivity indicator

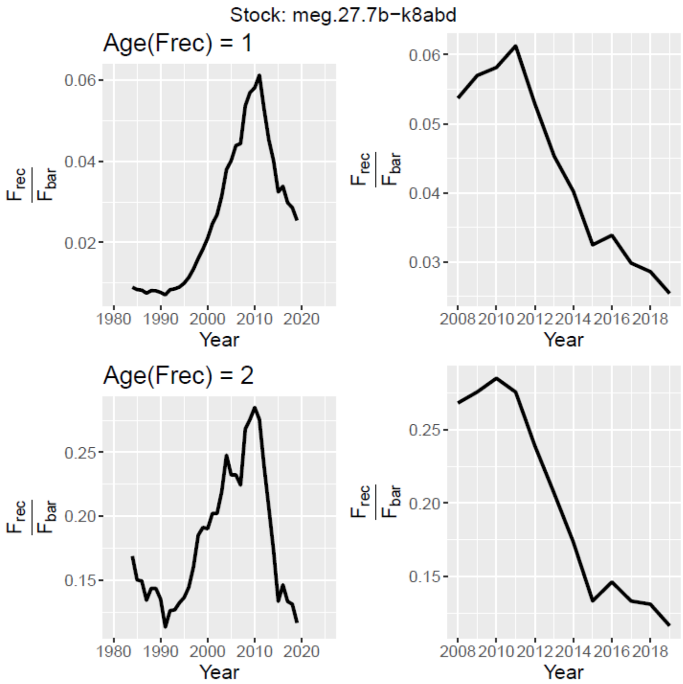

Figure 38: Celtic Sea megrim. Time-series of Selectivity indicator F_{rec}/F_{bar}. Top (Frec = 0) left: full time series; Top right: reduced time series ; Bottom (Frec = 1) left: full time series; Bottom right: reduced time series.

The indicator pattern at age 1 shows a steady increase from 1995, peaking in 2011, with a sharp decline to the present. The indicator level is still higher than in the 1980s , but in any case is very low at less than 0.15. The same pattern can be seen for the age 2 fish, with a stronger decline by 2020 back to the value in 1990. The key break year is 2010-11. There were no major technical changes at this time, although in 2012, there was an increase in the mesh size of the SMPs. Coupled with a date after the decline started, it is also probably unlikely that megrim would be particularly likely to escape from an SMP in the top of the extension. The change may be due to effort reduction.

Achievement of objective and targets (Article 3 and 4)

The level of the indicator has declined sharply to very low levels in 2020 for both age classes, suggesting that selectivity for young fish is good and has significantly improved over the last 10 years. No links with technical measures or management could be determined.

Western Channel plaice

General stock trends

The following stock summary is taken from ICES advice (ICES 2020a).

Current assessment is type 3 – survey based assessment trends. Fishing mortality (F) declined substantially after 2007, but has increased again since 2015 and is currently above FMSY. The spawning-stock biomass (SSB) has increased substantially since 2008, is currently well above MSYBtrigger but has been decreasing since 2016. Recruitment (R) in the last three years has been below the long-term average.

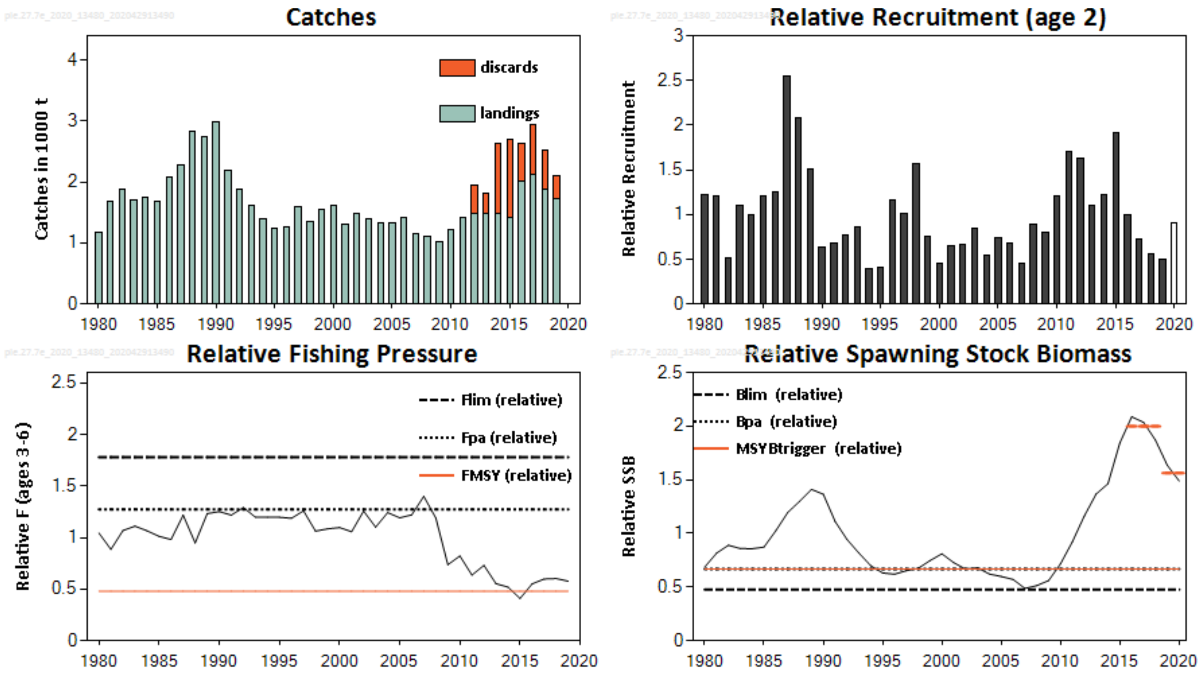

Figure 39: Western Channel plaice. Summary of the stock assessment. Figure taken from ICES 2020g.

Timeline

“Major” measures since 2010 are highlighted in yellow

1998 – New technical measures Regulation introduces limited improvements in selectivity, including the use of 80mm codend mesh size in demersal fisheries in the Western Channel including beam trawls.

2007 – Multiannual plan for sole introduced into the western Channel which introduces and effort and TAC restrictions. Plaice as an associated species impacted.

2018 – All catches of sole with beam trawls subject to the Landing Obligation. De minimis exemption introduced to allow discarding of unwanted catches of sole linked to requirement to use 120mm Flemish panel. Likely benefits for plaice.

2019 – WWMAP introduced for stocks in WW and multiannual plan for sole is repealed. Effort restrictions effectively removed.

2019 – Technical measures framework regulation introduces new baseline mesh size ranges for the Celtic Sea with a general increase in mesh size to 100mm. Derogation for vessels targeting sole with beam trawls to use 80mm with 180mm headline panel.

2019 – All catches of plaice subject to the Landing Obligation. Survival exemption introduced to allow discarding of unwanted catches of plaice caught in demersal trawl, beam trawl and static net fisheries in 7e.

Selectivity indicator

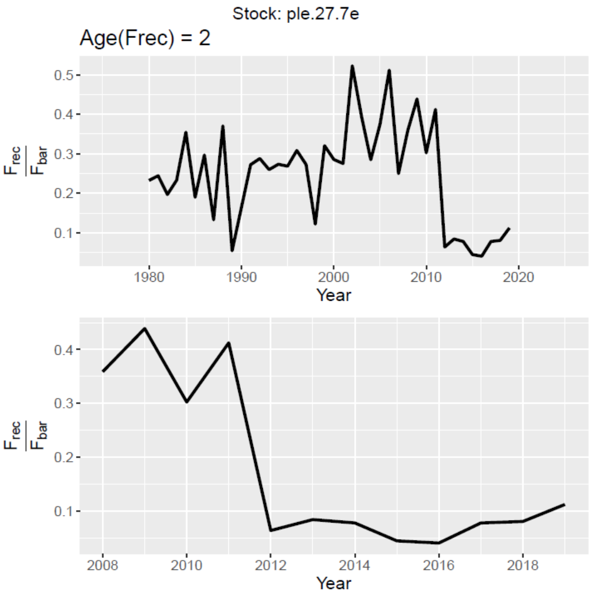

Figure 40: Western Channel plaice. Time-series of Selectivity indicator F_{rec}/F_{bar}. Top: full time series; Bottom: reduced time series.

The pattern in the indicator shows a noisy, but steady slow trend rising from 0.2-0.3 in the 1980s, to perhaps 0.3-0.4 in 2011. This was followed by a sharp decline to under 0.1, though it has risen again from 2016 to now. There is no obvious technological or management change that might explain this substantial change. Although it does coincide with a decrease in overall F (but only just to Fmsy) just before 2011, a following rise in the SSB until 2016, and recruitment was strong over the same period.

Achievement of objective and targets (Article 3 and 4)

The level of the indicator declined to low levels in 2020, suggesting that selectivity for young fish is good and has significantly improved over the last 10 years. No links with technical measures or management could be determined.

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South Western Waters

This study focuses on six stocks of the geographical area of South Western Waters (SWW), which means ICES zones VIII, IX and X (waters around Azores), and CECAF zones (2) 34.1.1, 34.1.2 and 34.2.0 (waters around Madeira and the Canary Islands). In this case all the stocks are in VIII and IX but some of them are found in other zones. There are two stocks of Hake, three of megrim and one of whiting. For each stock, the major technical measures are listed, which have been adopted to protect the juveniles. Using a selectivity indicator, a possible relation between them and the state of the stock is described.

Hake (*Merluccius merluccius*) in subareas 4, 6, and 7, and in divisions 3.a, 8.a–b, and 8.d, Northern stock (Greater North Sea, Celtic Seas, and the northern Bay of Biscay)

General stock trends

The spawning stock biomass (SSB) has increased substantially since 2006. In 2016, it reached the maximum in the time series, and since then it has declined slightly. Fishing mortality (F) decreased markedly between 2005 and 2012, and has been stable below FMSY since then. Recruitment is variable without trend with recent increase in uncertainty in recent recruitment estimates.

The EU landing obligation was implemented from 1 January 2017 for several gears, including otter trawlers with >100 mm(ICES 8abd) , longlines and gill nets (EURegulation 2016/2374). From 2019, hake is fully under the EU landing obligation. The following stock summary is taken from ICES advice (ICES 2020a).

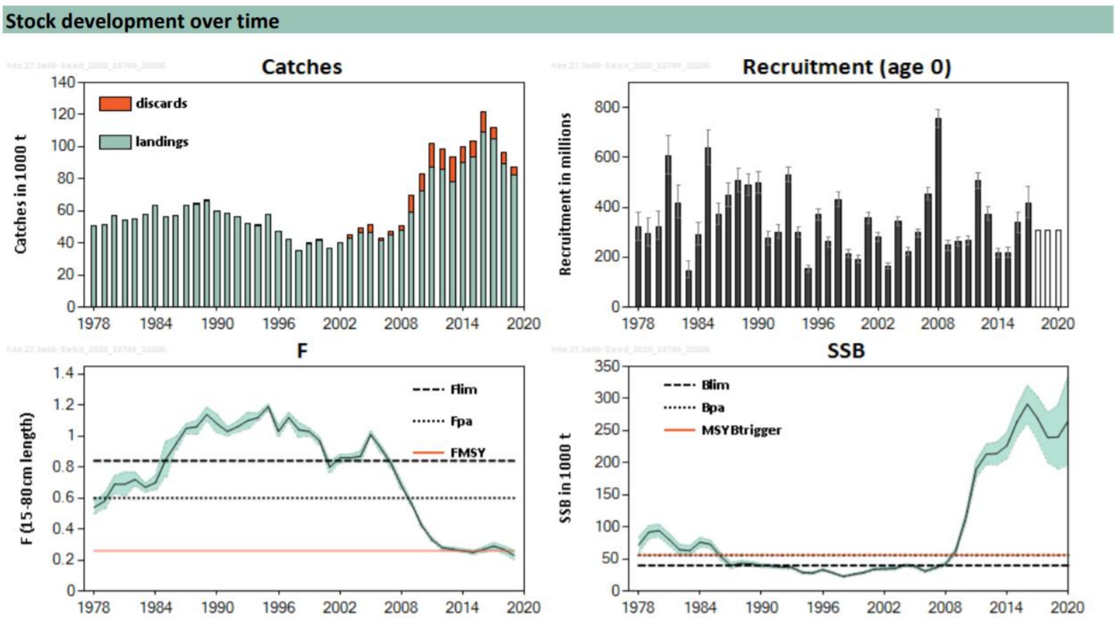

Figure 41: Hake (Merluccius merluccius) in subareas 4, 6, and 7, and in divisions 3.a, 8.a–b, and 8.d, Northern stock. Summary of the stock assessment I. Figure taken from CES 2020g.

The timeline of the technical measures and other changes that could have potentially affected the selectivity of this stock is as follows:

- 1998 – EU 850/1998 regulation: MCRS set at 27cm
- 1999 – EU 1441/1999 regulation: codend minimum mesh size set at 70mm
- 2004 – «Hake box» protection zone: codend minimum mesh size set at 100mm or 70mm codend with 100mm square mesh panel
- 2005 – 100mm square mesh panel in the Nephrops fishery of the bay of Biscay
- 2013 – EU 227/2013 regulation restricted fishing for tramel and gillnet between 0 and 200m
- 2015 – 12/02/2015 national regulation : vessels targetting sole increased codend mesh size to 80mm
- 2016 EU Regulation 2016/2374) establishing a discard plan for certain demersal fisheries in South-Western Waters

Relevant/major technical measures

The major technical measure implemented in this area (ICES 8abd) was the SMP (square mesh panel) of 100 mm in the upper plan of the codend to reduce gadids discards.

Selectivity indicator

The proposed selictivity indicator was developped for using fish-stock assessment outputs by age, whether those are F at age or Fbar estimates. The ICES assessment model for hake is a length based model, which uses length-based input data. Although, the model in question does work internally with age rather than length, the age slicing mechanics are not known. The potentially provided F at age could be used to estimate Frec/Fbar, if the Fbar age-range was known. The given Fbar is for a size range, which could be used if growth information or the age-slicing parameters were available. This pecularity is due to the difficulty of ageing hake consistently and correctly.

Hake (*Merluccius merluccius*) in divisions 8.c and 9.a, Southern stock (Cantabrian Sea and Atlantic Iberian waters).

General stock trends

The stock-size indicator is variable, although it shows a historical upward trend. It has decreased slightly in recent years.

The EU landing obligation was implemented from 1 January 2017 for several gears, including otter trawlers with >70 mm mesh (ICES8c,9a), longlines and gill nets (EURegulation 2016/2374). From 2019, hake is fully under the EU landing obligation. The following stock summary is taken from ICES advice (ICES 2020a).

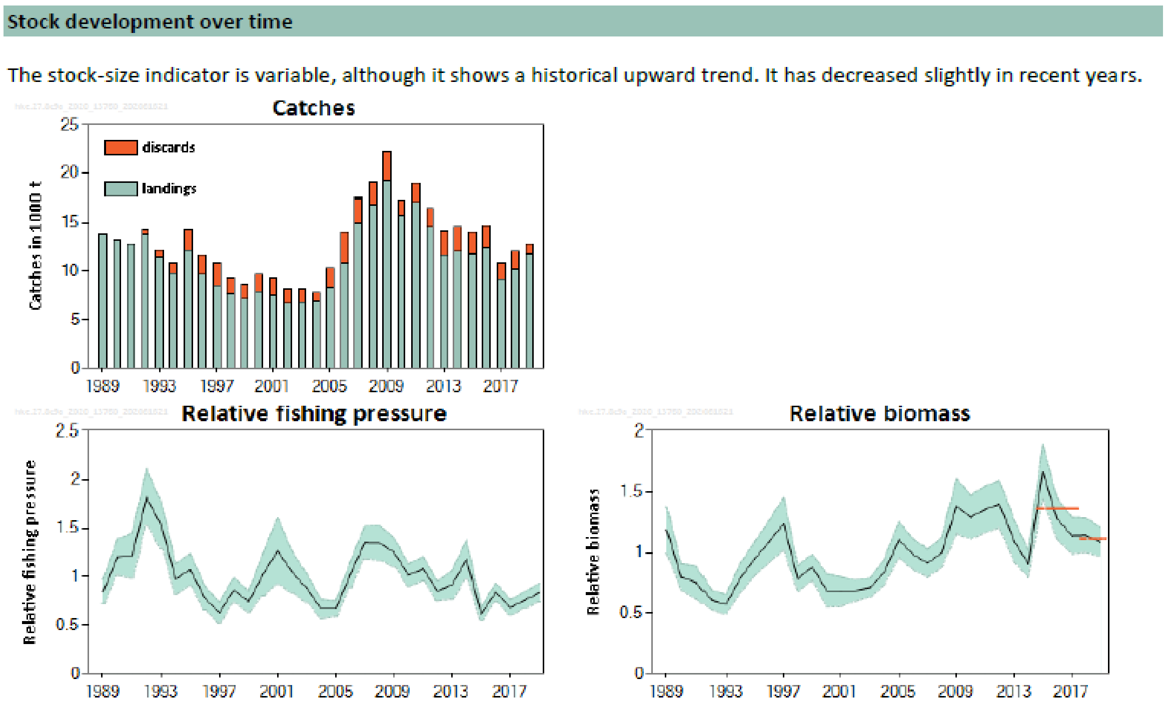

Figure 42: Hake (Merluccius merluccius) in divisions 8.c and 9.a, Southern stock. Summary of the stock assessment. Taken from Figure taken from ICES 2019e

The timeline of the technical measures and other changes that could have potentially affected the selectivity of this stock is as follows:

- 2015 - Orden AAA/2534/2015. Closed area in the 9a from 1 december to the last day of February.
- 2016 - EU Regulation 2016/2374) establishing a discard plan for certain demersal fisheries in South-Western Waters

Relevant/major technical measures

There are not relevant technical measures for hake in this area apart of landing obligation measures (including De minimis exceptions).

Selectivity indicator

The same as for hke.27.3a46-8abd is true here, with the caveat that no F at age data was available due to delays in the validation of this year’s assessment:

The proposed selictivity indicator was developped for using fish-stock assessment outputs by age, whether those are F at age or Fbar estimates. The ICES assessment model for hake is a length based model, which uses length-based input data. Although, the model in question does work internally with age rather than length, the age slicing mechanics are not known. The **potentially** provided F at age could be used to estimate Frec/Fbar, if the Fbar age-range was known. The given Fbar is for a size range, which could be used if growth information or the age-slicing parameters were available. This pecularity is due to the difficulty of ageing hake consistently and correctly.

Megrim (*Lepidorhombus whiffiagonis*) in divisions 7.b–k, 8.a–b, and 8.d (west and southwest of Ireland, Bay of Biscay)

General stock trends

Management of catches of the two megrim species, *Lepidorhombus whiffiagonis* and *L. boscii*, under a combined species TAC, prevents effective control of the single-species exploitation rates and could lead to the overexploitation of either species.

The EU landing obligation was implemented from 1 January 2019 for all gears for this species. The following stock summary is taken from ICES advice (ICES 2020a).

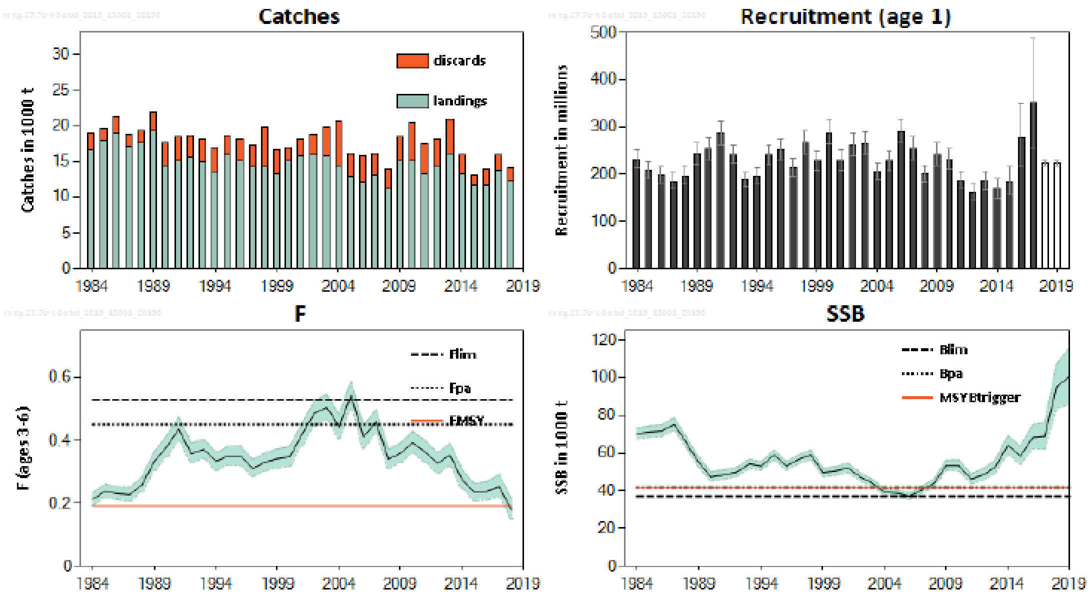

Figure 43: Megrim (Lepidorhombus whiffiagonis) in divisions 7.b–k, 8.a–b, and 8.d. Summary of the stock assessment. Figure taken from ICES 2019c

The timeline of the technical measures and other changes that could have potentially affected the selectivity of this stock is as follows:

- 1998-2019 - EU 850/98 to EU 2019/1241 regulations: progressive switch of 80mm codend to 100mm codend
- 2013 – EU 224/2013: Porcupine area closed from 01/05 to 31/05
- 2020 – EU 123/2020: Raised fishing line added to the selective devices implemented by EU 2018/2034 regulation
- 2015 – 12/02/2015 national regulation: vessels targetting sole increased codend mesh size to 80mm

No technical measure focused specifically on megrim protection, but the increased codend mesh size to 80mm for vessel tagetting sole may reduce catches of juveniles of megrim. Square mesh panels have probably very low effect on megrim escapement.

No technical measure focused specifically on megrim protection (apart of landing obligation measures, including De minimis exceptions). However, the increased codend mesh size to 80mm for vessel tagetting sole may help to reduce catches of juveniles of megrim in the Bay of Biscay.

Relevant/major technical measures

No specific technical measure focused specifically on megrim protection apart of landing obligation measures (including De minimis exceptions).

Selectivity indicator

For this stock, the fully selected age range (the range of Fbar) is age 2 to age 4. As the selectivity indicator (Frec/Fbar) measures the relation of the fishing mortality in juvenile age classes to the fully recruited age classes, we decided to check both year classes below the lowest fully recruited year class (age(Frec) = {0,1}) ; this is only possible since age class 0 is estimated. In both cases the indicator shows an increase until 2010, alebeit at completely different scales. Age class 0 is barely selected at all throughout the time-series, as can be seen by the value of the indicator (Frec/Fbar < 0.07). A different story appears for age class 1, the values of Frec/Fbar reach a maximum in 2010 of more than 0.3. Since 2010, the indicator shows a steady decrease in both age classes. No technical measures were dedicated to the explicit protection of megrim .

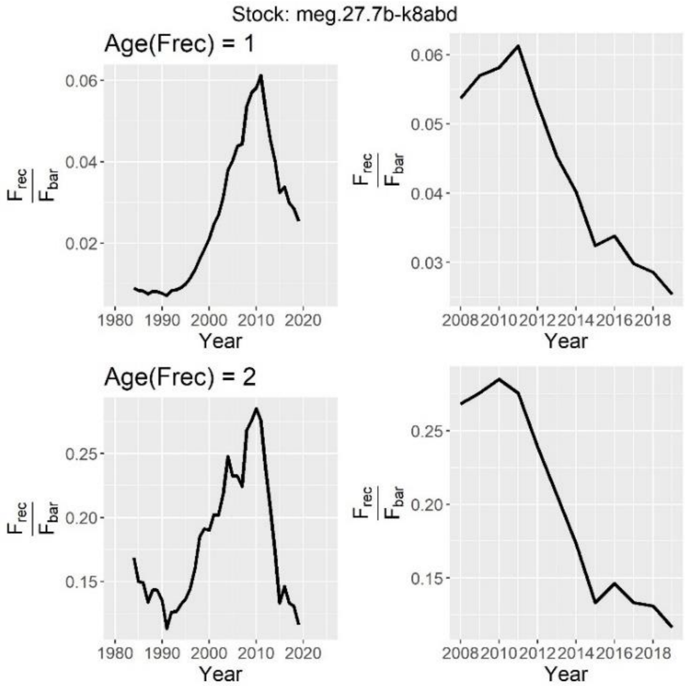

Figure 44: Hake. Time-series of Selectivity indicator F_{rec}/F_{bar}. Top (Frec = 0) left: full time series; Top right: reduced time series ; Bottom (Frec = 1) left: full time series; Bottom right: reduced time series.

Conclusion: achievement of objectives and targets

The trend of selectivity indicator shows a global improvement of juveniles protection but the high variability along the years indicates a relatively instable situation. There are no technical measures directly focused on this stock so the reason of this positive trend is unclear.

Four-spot megrim (*Lepidorhombus boscii*) in divisions 8.c and 9.a (southern Bay of Biscay and Atlantic Iberian waters East)

General stock trends

ICES advises that when the EU multiannual plan (MAP) for Western Waters and adjacent waters is applied, catches in 2021 that correspond to the F ranges in the MAP are between 1148 tonnes and 2375 tonnes. According to the MAP, catches higher than those corresponding to FMSY (1690 tonnes) can only be taken under conditions specified in the MAP, whilst the entire range is considered precautionary when applying the ICES advice rule. The following stock summary is taken from ICES advice (ICES 2020a).

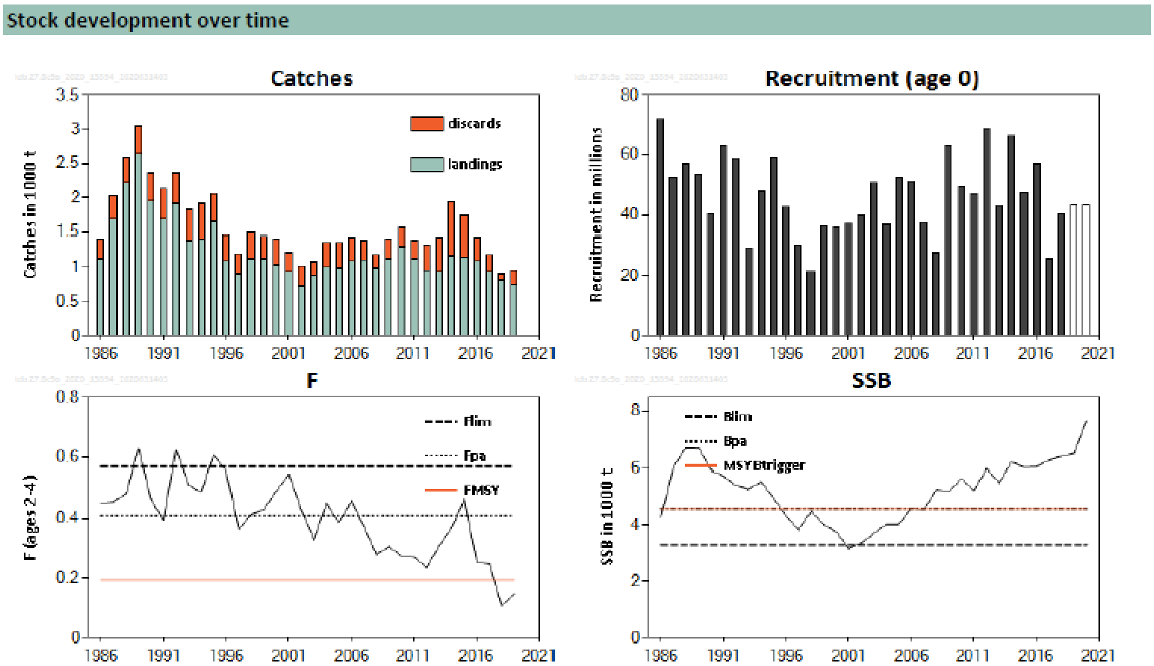

Figure 45: Four-spot megrim (Lepidorhombus boscii) in divisions 8.c and 9.a. Summary of the stock assessment. Figure taken from ICES 2019a

Timeline of technical measures

- 1998 – EU 850/1998 regulation: MCRS set at 27cm.
- 1999 – EU 1441/1999 regulation: codend minimum mesh size set at 70mm.
- 2015 - Orden AAA/2534/2015. Closed area in the 9a from 1 december to the last day of February.
- 2016 - EURegulation 2016/2374) establishing a discard plan for certain demersal fisheries in South-Western waters.

Relevant/major technical measures

There are not relevant technical measures for four spot megrim in this area apart of landing obligation measures (including De minimis exceptions).

Selectivity indicator

The selectivity indicator is highly volatile, it has large multi-annual spikes with troughs interspersed. Only age class 1 was under consideration as the assessment does not estimate lower age classes. It stays quite stable until the mid 1990s when it starts to rise until it reaches a peak in 1999, and then falls to a minimum in 2006. Then it increases again to reach a maximum of 0.9 around the year 2010. In the recent period a gradual downward trend can be noticed reaching 0.10. The evolution of the indicator points at a gradual improvement of the selectivity for the young fish after 2010.

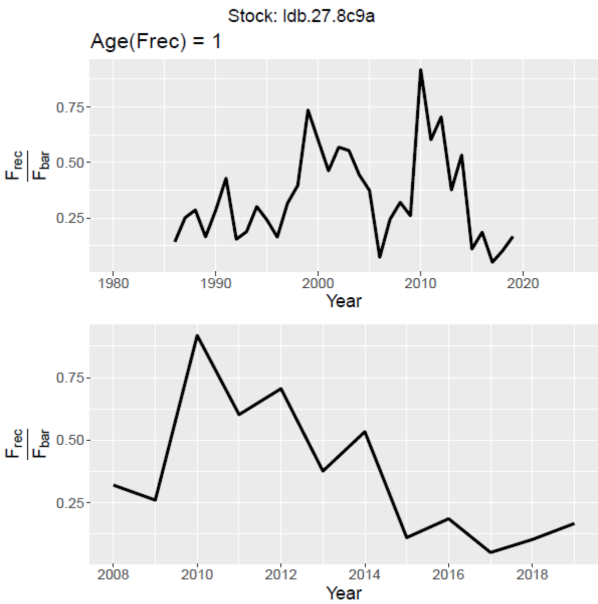

Figure 46: Four-spot megrim. Time-series of Selectivity indicator F_{rec}/F_{bar}. Top: full time series; Bottom: reduced time series.

Conclusion: achievement of objectives and targets

The trend of selectivity indicator shows a global improvement of juveniles protection but the high variability along the years indicates a relatively instable situation. There are no technical measures directly focused on this stock so the reason of this positive trend is unclear.

Megrim (*Lepidorhombus whiffiagonis*) in divisions 8.c and 9.a (Cantabrian Sea and Atlantic Iberian waters)

General stock trends

ICES advises that when the EU multiannual plan (MAP) for Western Waters and adjacent waters is applied, catches in 2021 that correspond to the F ranges in the MAP are between 312 tonnes and 571 tonnes. According to the MAP, catches higher than those corresponding to FMSY (468 tonnes) can only be taken under conditions specified in the MAP, whilst the entire range is considered precautionary when applying the ICES advice rule. The following stock summary is taken from ICES advice (ICES 2020a).

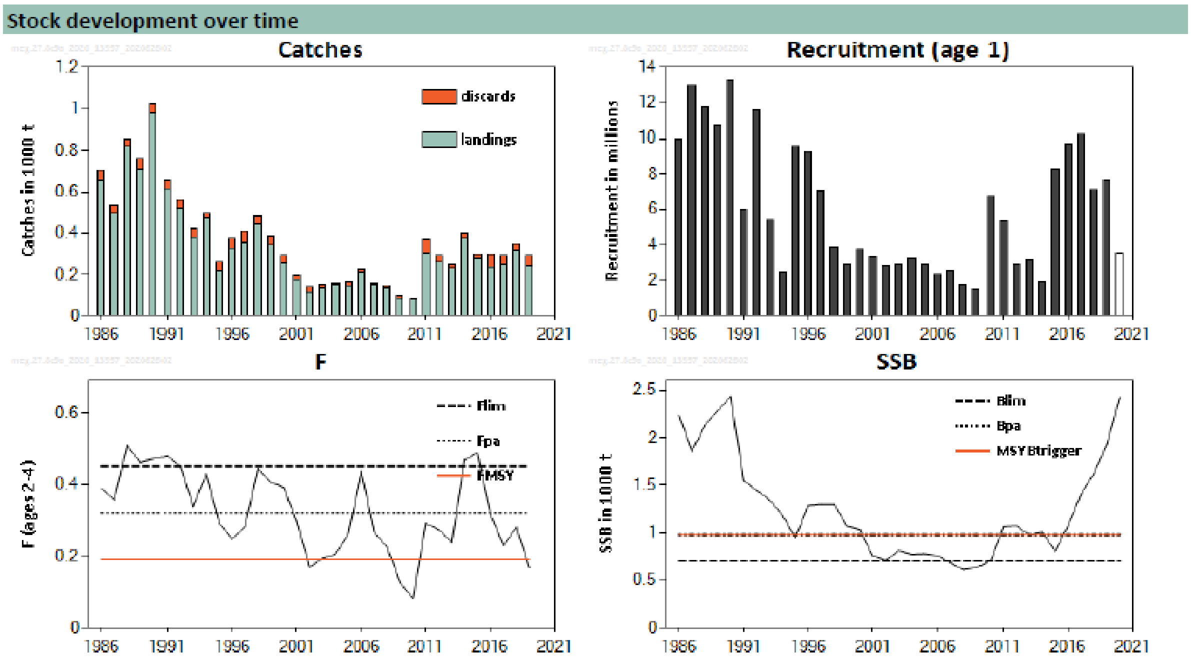

Figure 47: Megrim (Lepidorhombus whiffiagonis) in divisions 8.c and 9.a. Summary of the stock assessment. Figure taken from ICES 2019c

Timeline of technical measures

- 1998 – EU 850/1998 regulation: MCRS set at 27cm.
- 1999 – EU 1441/1999 regulation: codend minimum mesh size set at 70mm.
- 2015 - Orden AAA/2534/2015. Closed area in the 9a from 1 december to the last day of February.
- 2016 EURegulation 2016/2374) establishing a discard plan for certain demersal fisheries in South-Western waters.

Relevant/major technical measures

There are not relevant technical measures for megrim in this area apart of landing obligation measures (including De minimis exceptions).

Selectivity indicator

The selectivity indicator starts below 0.4 at the beginning of the time series in the middle of 1980's. It stays quite stable with large fluctuations till the year 2011 when it increases to reach a maximum of 1.7. A gradual decrease occurred until 2018 reaching 0.10. The evolution of the indicator points at a gradual improvement of the selectivity for the young fish after 2011.

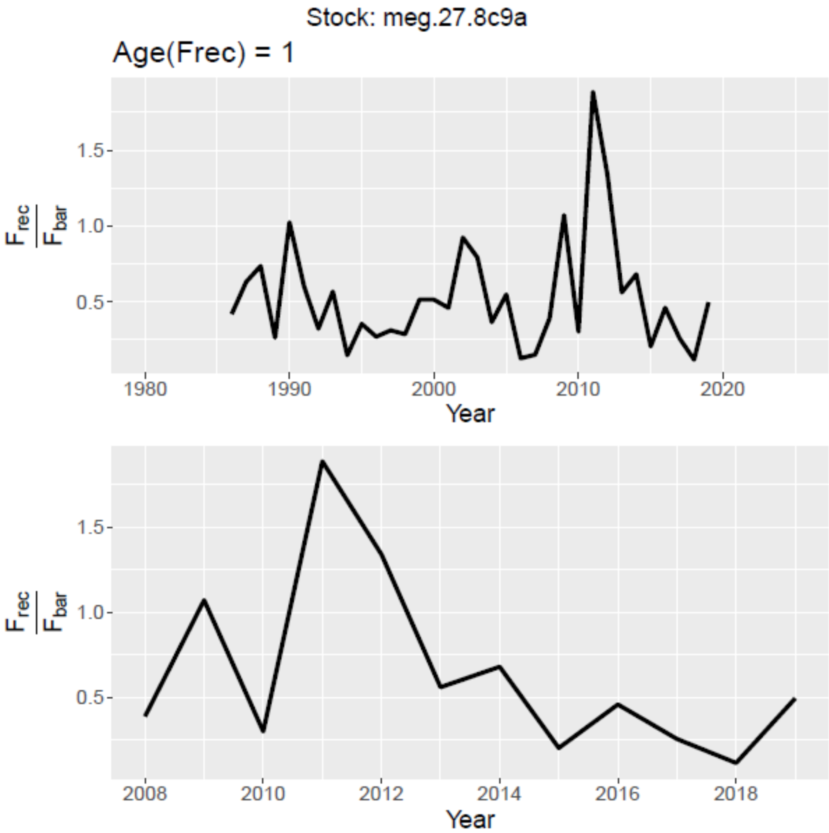

Figure 48: Megrim. Time-series of Selectivity indicator F_{rec}/F_{bar}. Top: full time series; Bottom: reduced time series.

Conclusion: achievement of objectives and targets

The trend of selectivity indicator shows a global improvement of juveniles protection but the high variability along the years indicates a relatively instable situation. There are no technical measures directly focused on this stock so the reason of this positive trend is unclear.

Whiting (Merlangius merlangus) in Subarea 8 and Division 9.a (Bay of Biscay and Atlantic Iberian waters)

General stock trends

ICES advises that when the precautionary approach is applied, catches in each of the years 2019, 2020, and 2021 should be no more than 2276 tonnes.

Stock development over time

Landings have been fluctuating without trend over the time period and have decreased in the last three years. Discard rates have been stable.

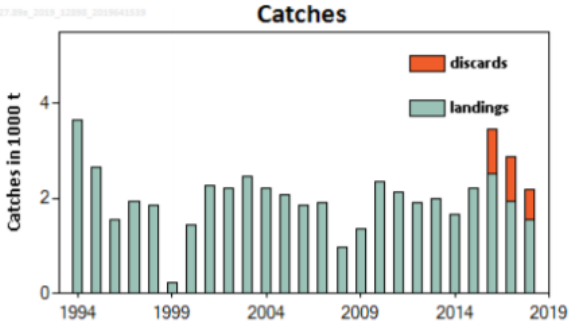

Figure 49: Whiting (Merlangius merlangus) in Subarea 8 and Division 9.a. Summary of the stock assessment. Figure taken from ICES 2019d

The timeline of the technical measures and other changes that could have potentially affected the selectivity of this stock is as follows:

- 2004 – EU regulation : set 100mm codend or 70mm codend with a square mesh panel of 100mm in the hake protection area
- 2015 – 12/02/2015 national regulation: vessels targetting sole increased codend mesh size to 80mm

The implementation of square mesh panel aim at reducing gadoids by catches. The following stock summary is taken from ICES advice (ICES 2020a).

Relevant/major technical measures

The major technical measure implemented in this area (ICES 8abd) was the SMP (square mesh panel) of 100 mm in the upper plan of the codend to reduce gadids discards.

Selectivity indicator

No data available

References

ICES. 2019a. Megrim (*Lepidorhombus whiffiagonis*) in divisions 8.c and 9.a (Cantabrian Sea and Atlantic Iberian waters). In Report of the ICES Advisory Committee, 2019. ICES Advice 2019 meg.27.8c9a, https://doi.org/10.17895/ices.advice.4764

ICES. 2019b. Four-spot megrim (Lepidorhombus boscii) in divisions 8.c and 9.a (southern Bay of Biscay and Atlantic Iberian waters East). In Report of the ICES Advisory Committee, 2019. ICES Advice 2019, ldb.27.8c9a, https://doi.org/10.17895/ices.advice.4762

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ICES. 2020e. Hake (Merluccius merluccius) in divisions 8.c and 9.a, Southern stock (Cantabrian Sea and Atlantic Iberian waters). In Report of the ICES Advisory Committee, 2020. ICES Advice 2020, hke.27.8c9a. https://doi.org/10.17895/ices.advice.5886

ICES. 2019f. Hake (Merluccius merluccius) in subareas 4, 6, and 7, and divisions 3.a, 8.a –b, and
8.d, Northern stock (Greater North Sea, Celtic Seas, and the northern Bay of Biscay). In Report of the ICES Advisory
Committee, 2019. ICES Advice 2019, hke.27.3a46-8abd, https://do Advice i.org/10.17895/ices.advice.4759

Mediterranean

Background

The Mediterranean Sea is divided into Geographical Sub-Areas (GSAs). These "national" GSAs boundaries do not match in some cases the natural barriers of stocks as they are rather based on geo-economic or political aspects**.**

This study focuses on 5 Mediterranean stocks: European hake GSAs 1-5-6,7; European hake GSAs 9-10-11; Deep water rose shrimp GSAs 9-10-11; Stripped Red Mullet GSA 5; Red mullet GSAs 17-18.

The core of EU Mediterranean fisheries management measures are set out in the EU Regulation 1343/2011 of the European Parliament and of the Council. This regulation establishes certain provisions for fishing in the GFCM (General Fisheries Commission for the Mediterranean) Area of application, High seas and National waters.

It amended Council Regulation (EC) No. 1967/2006 concerning management measures for the sustainable exploitation of fishery resources in the Mediterranean Sea.

In Mediterranean, management system leans mainly in Technical Regulations. Opposite to the Atlantic fishing management system, there are no TACs and quotas in Mediterranean fisheries, with the exception of the bluefin tuna, swordfish and some local management plan [9-23].

West Med Regulation

Western Mediterranean Sea Regulation [6] was enforced in 2019 for the GFCM geographical sub-areas (GSAs) 1 (Northern Alboran Sea), 2 (Alboran Island), 5 (Balearic Islands), 6 (Northern Spain), 7 (Gulf of Lions), 8 (Corsica Island), 9 (Ligurian and North Tyrrhenian Sea), 10 (South Tyrrhenian Sea) and 11 (Sardinia Island), as defined in Annex I of [4].

This Regulation applies to the following six stocks:

- Blue and red shrimp (GSAs 1, 5, 6, 7)
- Deep-water rose shrimp (GSAs 1, 5, 6, 9, 10, 11)
- Giant red shrimp (GSAs 9, 10, 11)
- Hake (GSAs 1, 5, 6, 7, 9, 10, 11)
- Norway lobster, (GSAs 5, 6, 9, 11)
- Red mullet (GSAs 1, 5, 6, 7, 9, 10, 11)

Species and size selectivity of fishing gear

Table 9. Technical measures influencing gear selectivity in the Mediterranean Sea specified for each fishing gear. ANE: Engraulis encrasicolus; SBR: Pagellus bogaraveo; PIL: Sardina pilchardus.

Area	Gears	Technical Measure	Target species	EC Reg. Ref.
Mediterranean Sea	Bottom trawls	Minimum mesh size of bottom trawlers 40 mm square or 50 mm diamond. Twine thickness 3 mm in codend-6 mm in the body. The circumference of the rearmost part of the trawl body (the tapered section) or of the extension piece (the untapered section) shall not be smaller than the circumference of the front end of the codend *sensu stricto*. In the case of a square mesh codend, in particular, the circumference of the rearmost part of the trawl body or of the extension piece shall be from two to four times the circumference of the front end of the codend *sensu stricto*.	-	[3]
	Pelagic Trawls	Pelagic trawl nets targeting sardine and anchovy, (where these species account for at least 80 % of the catch in live weight after sorting), have a minimum mesh size of 20 mm.	ANE, PIL	
	Purse seines	For surrounding nets the minimum mesh size is 14 mm.	-	
		The length of purse seines and seines without purse lines shall be restricted to 800 m with a drop of 120 m, except in the case of purse seines used for directed fishing of tuna.		
	Bottom-set gillnets	Bottom-set gillnets shall not have a mesh size opening smaller than 16 mm.	-	
		Prohibited to use the following static nets: a) A trammel net with a drop of more than 4 m; b) A bottom set gillnet or combined trammel and gillnet with a drop of more than 10 m except when such nets are shorter than 500 m, where a drop of not more than 30 m is permitted. c) Prohibited to use any gillnet, entangling net or trammel net constructed with a twine thickness greater than 0.5 mm.		
		Prohibited to have on board or set more than 2500 m of combined gillnets and trammel nets and 6000 m of any gillnet, entangling net or trammel net.		
	Gillnets, entangling	Minimum mesh size of 100 mm.	SBR	

Area	Gears	Technical Measure	Target species	EC Reg. Ref.
	nets or trammel nets			
	Longlines	Prohibited with hooks of a total length of less than 3.95 cm and a width of less than 1.65 cm	SBR	
		It shall be prohibited for vessels fishing with bottom-set longlines to have on board or deploy more than 5 000 hooks except for vessels undertaking fishing trips of more than 3 days, which may have on board or deploy no more than 7 000 hooks.	-	
		It shall be prohibited for vessels fishing with surface-set longlines to have on board or deploy more than the number of hooks per vessel as follows: a) 2500 hooks when directed fishing for swordfish; and b) 5000 hooks when directed fishing for albacore tuna.		
	Dredges	The maximum breadth of dredges shall be 3 m, except for dredges used for directed fishing of sponges.	-	
	All gears	Landing obligation for regulated species[3,4].	Species with MCRS [3, 7]	[3, 5, 7]
Western Mediterranean Sea	Bottom trawls	**Fishing effort regime** applied to all vessels fishing with trawls in the areas.	-	[6]
		Fishing operations limited to a maximum of 15 hours per fishing day, five fishing days per week or equivalent. Member States may grant a derogation of up to 18 hours per fishing day to take into account the transit time between port and the fishing ground.		

[3] From 1 January 2017 at the latest for species which define the fisheries and from 1 January 2019 at the latest for all other species in fisheries not covered by point (a) in the Mediterranean, in the Black Sea and in all other Union waters and in non-Union waters not subject to third countries' sovereignty or jurisdiction.

[4] From 1 January 2015 at the latest: *i)* small pelagic fisheries (i.e. fisheries for mackerel, herring, horse mackerel, blue whiting, boarfish, anchovy, argentine, sardine, sprat); *ii)* large pelagic fisheries (i.e. fisheries for bluefin tuna, swordfish, albacore tuna, bigeye tuna, blue and white marlin); *iii)* fisheries for industrial purposes (inter alia, fisheries for capelin, sandeel and Norwegian pout); *iv)* fisheries for salmon in the Baltic Sea.

Area	Gears	Technical Measure	Target species	EC Reg. Ref.
		Use of trawls in the western Mediterranean Sea prohibited within six nautical miles from the coast except in areas deeper than the 100 m isobath during three months each (derogation: Member States may establish, on the basis of the best available scientific advice, other closure areas, provided that a reduction of at least 20 % of catches of juvenile hake in each geographical subarea is achieved).		

Closed or restricted areas to protect juveniles and spawning aggregations

Fisheries Restricted Areas (FRAs) [4] preserving fisheries related resources, and protecting specific and vulnerable habitats:

1. Eastern Gulf of Lions
2. East of Adventure Bank (Sicily)
3. Buffer area bound in the strait of Sicily
4. Jabuca pomo pit
5. Alboran sea
6. Lophelia reef off Capo Santa Maria di Leuca

Table 10. Closed or restricted areas in the Mediterranean Sea specified by gear and target species. ANE: Engraulis encrasicolus; FIM: Aphia minuta; SPC: Spicara smaris; EDE: Pseudaphya ferreri; ZGC: Gymnammodytes cicerelus; ZGS: Gymnammodytes semisquamatus; YTN: Crystallogobius linearis; VEX: Venus spp.; DXL: Donax trunculus; PIL: Sardina pilchardus.

Gears	Area	Technical Measure	Target species	EC Reg. Ref.
Bottom and Pelagic Trawls Shore and Boat Seines	Whole Med	Prohibited within 3 nm off the coast or within the 50 m isobath where that depth is reached at a shorter distance from the coast.	Species with MCRS [3, 7]	[3, 7]
		Prohibited within 1.5 nm off the coast.		
		Prohibited above seagrass beds of, in particular, *Posidonia oceanica* or other marine Phanerogams.		
		Prohibited above coralligenous habitats and mäerl beds.		
	West Med	Prohibited within six nautical miles from the coast except in areas deeper than the 100 m isobath during three months each year and, where appropriate, consecutively.	Stocks listed in Article 1 [6]	[6]
		By 17 July 2021 and on the basis of the best available scientific advice, the Member States concerned shall establish other closure areas where there is evidence of a high concentration of juvenile fish, below the minimum conservation reference size, and of spawning grounds of demersal stocks, in particular for the stocks concerned.		
Boat Seines derogations	Balearic islands	Management plan derogation for the distance from the coast and for the mesh size.	FIM, SPC, EDE	[3, 7-19]
	Murcia		FIM	
	Tuscany and Liguria (GSA 9)		FIM	
	Catalonia		FIM, ZGC, ZGS, YTN	
Shore seines	France (GSA 7)	Management plan derogation for the distance from the coast and for the mesh size.	Mixed species	[22]
Dredges	Whole Med	Authorised within 3 nm irrespective of the depth provided that the catch of species other than shellfish does not exceed 10 % of the total live weight of the catch.	VEX, DXL *(main target in hydraulic dredge)*	[3, 7]
		Prohibited above seagrass beds of, in particular,		

Gears	Area	Technical Measure	Target species	EC Reg. Ref.
		Posidonia oceanica or other marine *Phanerogams*.		
		Boat dredges and hydraulic dredges shall be prohibited within 0.3 nautical miles of the coast.		
		Prohibited above coralligenous habitats and mäerl beds.		
Purse seines	Whole Med	Prohibited within 300 meters of the coast or within the 50 metres isobath where that depth is reached at a shorter distance from the coast.	ANE, PIL	[3, 7]
		Deployment not allowed at depths less than 70 % of the overall drop of the purse seine itself.		
		If purse-line, the leadline or the hauling ropes do not touch the seagrass bed, may be authorised within management plans.		

Minimum conservation reference sizes

MCRS from Regulation (EU) No. 2019/1241 [7], amending Reg. (EC) No. 1967/2006 [3].

Species	All Med
Bass *(Dicentrarchus labrax)*	25 cm
Annular sea bream *(Diplodus annularis)*	12 cm
Sharpsnout sea-bream *(Diplodus puntazzo)*	18 cm
White sea-bream *(Diplodus sargus)*	23 cm
Two-banded sea-bream *(Diplodus vulgaris)*	18 cm
European anchovy *(Engraulis encrasicolus)*	9 cm(1)
Groupers (*Epinephelus* spp.)	45 cm
Stripped sea-bream *(Lithognathus mormyrus)*	20 cm
Hake *(Merluccius merluccius)*	20 cm
Red mullets (*Mullus* spp.)	11 cm
Spanish sea-bream *(Pagellus acarne)*	17 cm
Red sea-bream *(Pagellus bogaraveo)*	33 cm
Common Pandora *(Pagellus erythrinus)*	15 cm
Common sea bream *(Pagrus pagrus)*	18 cm
Wreckfish *(Polyprion americanus)*	45 cm
European sardine *(Sardina pilchardus)*	11 cm (2)(4)
Mackerel (*Scomber* spp.)	18 cm

Species	All Med
Common sole *(Solea vulgaris)*	20 cm
Gilt-head sea-bream *(Sparus aurata)*	20 cm
Horse mackerel (*Trachurus* spp.)	15 cm
Norway lobster *(Nephrops norvegicus)*	20 mm CL(3) 70 mm TL(3)
Lobster *(Homarus gammarus)*	105 mm CL(3) 300 mm TL(3)
Crawfish (*Palinuridae*)	90 mm CL(3)
Deepwater rose shrimp *(Parapenaeus longirostris)*	20 mm CL(3)
Scallop *(Pecten jacobeus)*	10 cm
Carpet Clams (*Venerupis* spp.)	25 mm
Venus shells (*Venus* spp.)	25 mm

(1) Member States may convert the minimum conservation reference size into 110 specimens per kg.

(2) Member States may convert the minimum conservation reference size into 55 specimens per kg.

(3) CL: carapace length; TL: total length.

(4) This minimum conservation reference size shall not apply to fries of sardine landed for human consumption if caught by boat seines or shore seines and authorised in accordance with national provisions established in a management plan as referred to in Article 19 of [3], provided that the stock of sardine concerned is within safe biological limits.

Innovative fishing gear

In response to the EU DG-MARE request on the progress and impact that has been made in innovative gear use within EU waters, the ICES WKING "Workshop on Innovative Fishing Gears" is developing a suite of criteria to objectively define "Innovative gear".

As both the WKING report and advice are not public yet, we assume that an Innovative gear is any *"new ideas, measure or gear modification in the form of technology or method that is sufficiently different from the standards specified in the current European Regulations"*.

According to the WKING TORs (https://www.ices.dk/community/Documents/Science EG ToRs/EOSG/2020/WKING TORs 2020.pdf), the report will contain a catalogue of Innovative gears from different European sea basins to provide an overview of the state-of-the-art technologies and innovations that are relevant to the European fisheries.

In the Mediterranean, among the different examples reported in the WKING report, a dual codend innovation, recently developed by Mediterranean fishers in collaboration with local net makers, is worth to be considered in this STECF EWG.

The dual codend has the upper-most codend manufactured with at least 54 mm diamond mesh. Fish and shrimps can pass through cuttings on the uppermost netting panel of the lower codend. This fishing gear modification does not use any separator or guiding, panel or grid to separate catches into two independent (dual) codends, but derive benefit from fish and shrimp swimming ability. Fish and shrimps are able to pass through the cuttings on the netting of the lower codend, leading to the upper codend, while debris ends in the lower codend.

Despite the dual codend was rapidly being used in many Med fisheries, as according to the legislative requirements of the Med Regulation [3,7] trawlers are limited to use one single codend, the innovation failed to scale up and being brought to market.

The possibility to use larger mesh sizes in the upper codend would make sense to facilitate greater reductions in undersize fish catches when needed, but a change to the current legislations would be required to permit trawl vessels to use the dual codend gear. Species separation in the dual codends greatly reduced catch sorting times, and likely improved both selectivity and catch quality. Hence, the dual codend gear could be extremely beneficial in that regard. The idea might have future development for facilitating species and size-selectivity using a more selective mesh size and/or type in the upper-most codend.

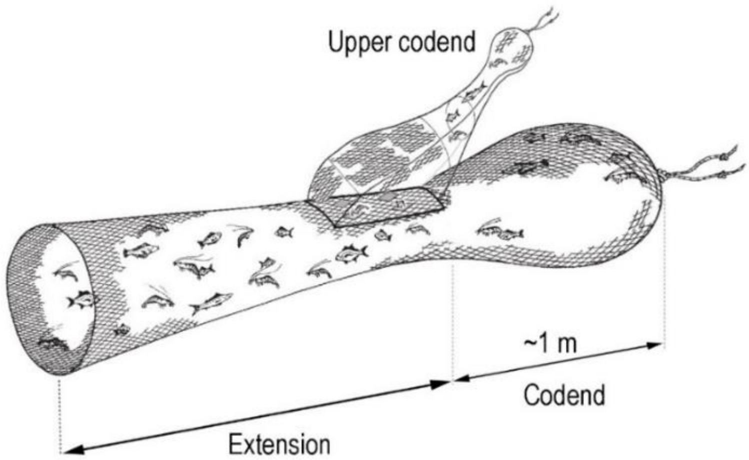

Figure 50. Dual codend innovation recently introduced in the Med bottom trawl fisheries.

Regional measures under temporary discard plans

Survivability and de minimis exemption exemption for all species with MCRS; changes in MCRS for Venus spp. (24- 27)

COMMISSION DELEGATED REGULATION (EU) 2020/3 of 28 August 2019 establishing a discard plan for Venus shells (*Venus* spp.) in certain Italian territorial waters: Survivability exemption for Venus shells (Venus spp.) and derogation from the minimum conservation reference size established in Annex IX to Regulation (EU) 2019/1241 [7], the minimum conservation reference size for Venus shells (*Venus* spp.) in Italian territorial waters of GFCM Geographical Sub-Areas GSA 9, 10, 17 and 18 shall be of a total length of 22 mm.

Pilot projects on full documentation of catches and discards

EFCA lasthauls

Article 104 of the Control Implementing Regulation (Regulation (EU) 404/2011)) specifies provisions for the monitoring of catches during fishing gear inspection. The European Fisheries Control Agency (EFCA) in cooperation with Member States has established Joint Deployment Plans (JDPs) separately for the Baltic Sea, North Sea, Western Waters and Mediterranean regions.

JDPs are coordinated by EFCA. One of the functions of the JDP s is collecting catch-composition data through the so-called "last haul analysis".

The last haul analysis is carried out by the inspection services after boarding a fishing vessel. In principle this provides similar information as a scientific observer collects but is focused on commercial fish species as well as catch fractions related to the landing obligation. However, it is limited to data from one specific haul which may or may not be representative of the fishing trip and is principally a source of data that can be cross-reference against other data sources, in particular observer, logbook and self-sampling data.

One drawback with the last haul analysis is in the use of the data due to confidentiality of professional and commercial secrecy (article 113 of the Control Regulation (EC) No 1224/2009 [8]. Therefore, if it were to be used as a further data source for the monitoring of effect on selectivity of new gears, these issues would need to be resolved.

ToR 2. Historic development in the state of indicators before and after the implementation of these measures (indicators are defined under 3-6)

The technical measures influencing selectivity and protecting juveniles in the Mediterranean are reported in Table 9 and Table 8, respectively. The technical measures comprise of the following categories:

a) species and size selectivity of fishing gear [2,3,7];

b) closed or restricted areas to protect juveniles and spawning aggregations [3,7,14-19];

c) MCRS [7].

In 2010, there was a change in selectivity in all fisheries. In bottom trawl fisheries, for example, the diamond 40 mm codend mesh was replaced by a square-meshed net of 40 mm at the codend or, at the duly justified request of the ship-owner, by a diamond meshed net of 50 mm.

Effect of these technical measures, related to the gear components, on gear selectivity have been largely studied. See for example Brčić et al., 2016; 2018a,b; Mytilineou et al., 2018; Sala et al., 2006; 2008; 2010; 2011; 2015; 2016.

During the period 2010 to 2019, no changes in technical measures influencing selectivity have been introduced (Table 11). While some changes have been introduced to close areas in order to protect juveniles and spawning aggregations (see Table 12).

The group examined the temporal development of the selectivity indicator Frec/Fbar in 16 different demersal stocks from the Western Mediterranean and the Adriatic Sea (STECF, 2019a; 2019b).

The majority of these stocks have been assessed by STECF using separable models resulting in an unchanged Frec/Fbar ratio over the years. However, five stocks were assessed using models that allowed population selectivity to vary over the years. These stocks were:

- Hake in GSAs 1,5,6,7 (Figure 51);
- Red mullet in GSAs 17,18 (Figure 52).
- Hake in GSAs 9,10,11 (Figure 53);
- Deep-water rose shrimp is GSAs 9,10,11 (Figure 54);
- Striped red mullet in GSA 5 (Figure 55);

The Frec/Fbar selectivity metric was tailored to the specific characteristics of every fish stock. The age-class chosen to calculate Frec was the first age–class for which some non-negligible harvest occurred (first recruited age-class), excluding the age-classes of Fbar. In the case of Deep-water rose shrimp in GSAs 9,10,11 Fbar was calculated over age–classes 1-2, while for the other stocks Fbar was calculated over age-classes 1-3. Hence, Frec was F-at-age 0 for all five stocks.

Table 11. Timeline of changes introduced by regulations influencing species and size selectivity of fishing gear.

Year	Technical Measure	Area	EC Reg. reference
1995	Minimum codend mesh size of 40 mm diamond		[2]
2010	Minimum codend mesh size of 40 mm square Minimum codend mesh size of 50 mm diamond	Whole Med	[Med Reg, 3]
2019	Reduction of Fishing effort regime Limitation of daily fishing activity to a maximum of 15 hours per fishing day, five fishing days per week or equivalent	West Med	[6]

Table 12. Timeline of changes introduced by regulations for closed or restricted areas to protect juveniles and spawning aggregations.

Year	Technical Measure	Area	EC Reg. reference
1995	Prohibition until 3 nm or 50 m depth off the coast	Whole Med	[2]
2010	Prohibition as before. Introduction 1.5 nm off the coast	Whole Med	[3]
2012	Introduction of FRAs 1. Eastern Gulf of Lions (GSA 7) 2. East of Adventure Bank (GSA 16) 3. Buffer area bound in the strait of Sicily (GSA 16) 4. Jabuca pomo pit (Adriatic Sea) (GSA 17) 5. Alboran sea (GSAs 1,2,3) 6. Lophelia reef off Capo Santa Maria di Leuca (GSA 19)	Whole Med	[4]
2019	Three months closure for an area six nm off the coast	West Med	[6]

Regional conclusions

The fact that most Mediterranean fish stocks are currently assessed using separable models, which assume stable population selectivity, hinders wider exploration of the temporal development of selectivity in the area.

The results from the evaluation of performance of technical measures suggest that the indicators have the capacity to detect changes in population selectivity (Figure 51-Figure 55). Trends in the selectivity indicators may relate to not only gear technical measures, but also to tactical changes in fishers behaviour. For a couple of the stocks examined (hake in GSAs 1,5,6,7; Figure 51; red mullet in GSAs 17,18; Figure 52) there was some evidence of an improvement in selectivity (lower values of Frec/Fbar) after 2010, when more selective codend mesh sizes were introduced (Table 11).

For both species, the selectivity indicator decreases below its initial values of around 0.35 for hake and 0.6 for red mullet from the years 2008-2009 onwards. For red mullet, there is a remarkable increase in the indicator during the last few years of the time series, which is worth to monitor. For this first two species the objective to protect juveniles seems to have been reached in the target GSAs, with a clear effect of the technical measures introduced in 2010. The 40 mm square- or 50 mm diamond-mesh of the codend, catching red mullet and hake in these areas, seem thus adequate to protect the youngest age classes, although for hake the difference over the time series is quite low in absolute numbers ranging 0.3-0.1.

For two others (striped red mullet in GSA 5; Figure 52; hake in GSAs 9,10,11; Figure 53), the fluctuations of selectivity did not exhibit any clear overall trend. For deep-water rose shrimp in GSAs 9,10,11, the time-series started in 2009 (Figure 54), so the effect from the 2010 regulation should be examined cautiously. Regarding temporal biomass patterns, increases have been observed for red mullet from 2008 onward, in several other Med GSAs (Vasilakopoulos et al., 2014; Tserpes et al., 2016; STECF 2016, Cardinale and Scarcella, 2017).

Such increases are in line with recent assessment studies suggesting that several Mediterranean red mullet stocks are in healthy condition, or at least in better situation than other deep-water stocks. It is likely that the implementation of Council Regulation (EC) No 1967/2006, which introduced additional trawling prohibitions in coastal areas, has contributed to this increase. Moreover, for both red mullet and striped red mullet the recruitment mainly occurs very close to the coast, at depths ranging 10-50 m. The implementation of satellite-based Vessel Monitoring Systems (VMS) through Council Regulation (EC) No 1224/2009 [8], has likely discouraged illegal fishing operations in coastal areas.

In conclusion, the technical measure introduced in 2010 (square-mesh codend or an increase in the minimum diamond-mesh size) does not seem to have a clear and detectable effect on these last three species in the investigated areas (Figure 53-Figure 55). Nevertheless, all these species mark a relative minimum of a downtrend in the recent years. Therefore, now also for these species, the objective to protect juveniles has been reached, although the variability of the selectivity indicator makes it difficult to assess this as a consistent effect related to the technical measures.

Regarding the last technical measures introduced by the MAP in western Mediterranean by the EU Regulation 1022/2019 [6], at moment is not possible to detect any possible influence on the chosen selectivity indicator. Noteworthy, it would have been interesting to investigate the effect of the closed areas introduced in 2012, especially in the GSA 17,18 for hake to protect spawning aggregations in the Jabuka pit. Unfortunately, now this is not possible as the interested stocks had been assessed by STECF using separable models resulting in an unchanged Frec/Fbar ratio over the years.

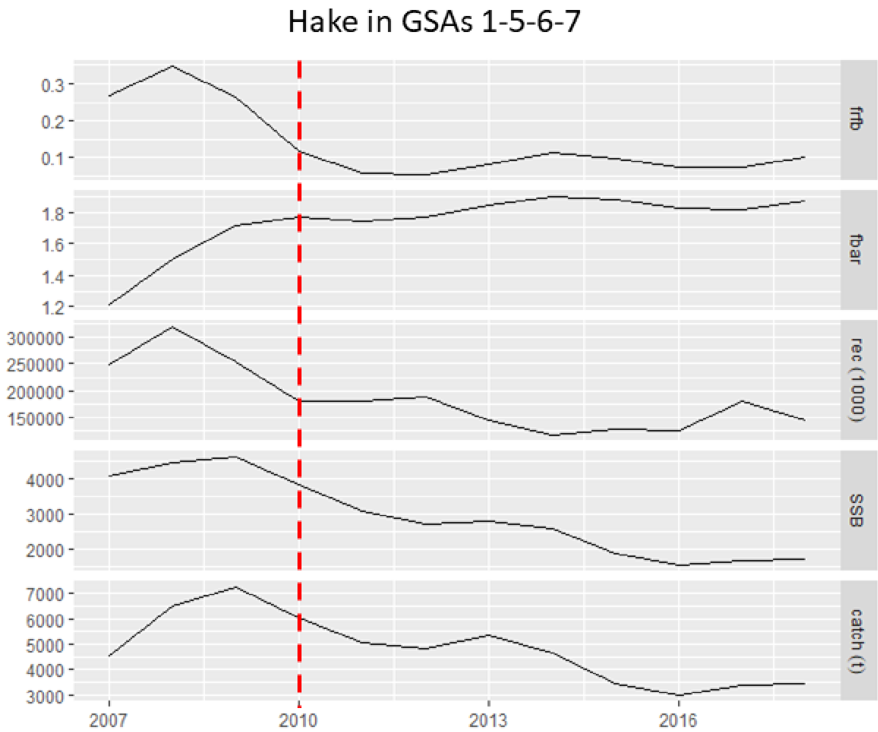

Figure 51. Hake in GSAs 1,5,6,7. Temporal development of the selectivity indicator (frfb) together with other key stock attributes. frfb: F of first recruited age-class (namely frec, age 0) divided by fbar (age 1-3); fbar: F of the fully exploited age-classes (1-3); rec(1000): recruitment; SSB: spawning-stock biomass; catch(t): catch in tonnes. Red dashed line at year 2010 represents the starting date of the Med Reg [3] implementation.

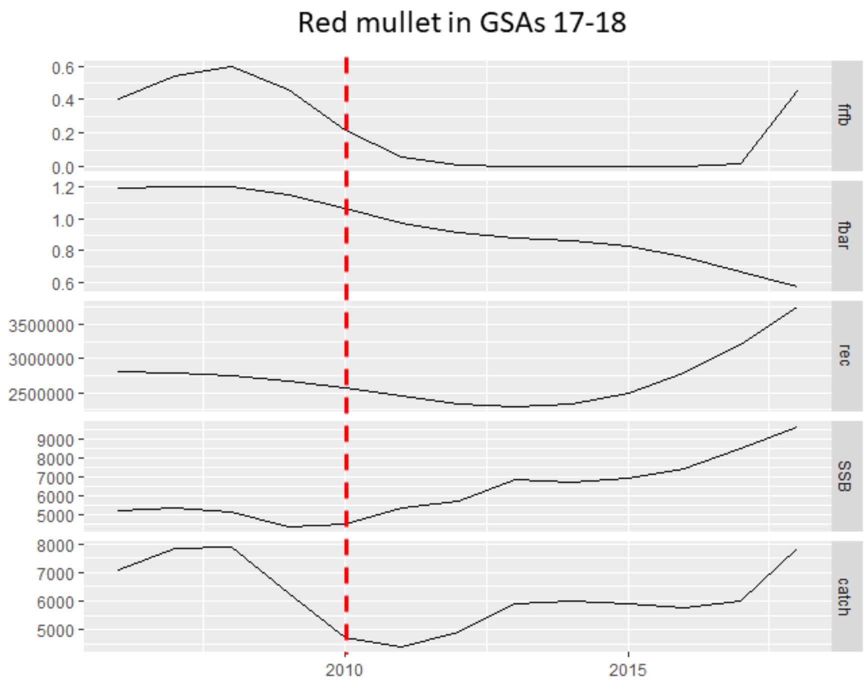

Figure 52. Red mullet in GSAs 17,18. Temporal development of the selectivity indicator (frfb) together with other key stock attributes. frfb: F of first recruited age-class (namely frec, age 0) divided by fbar (age 1-3); fbar: F of the fully exploited age-classes (1-3);

rec(1000): recruitment; SSB: spawning-stock biomass; catch(t): catch in tonnes. Red dashed line at year 2010 represents the starting date of the Med Reg [3] implementation.

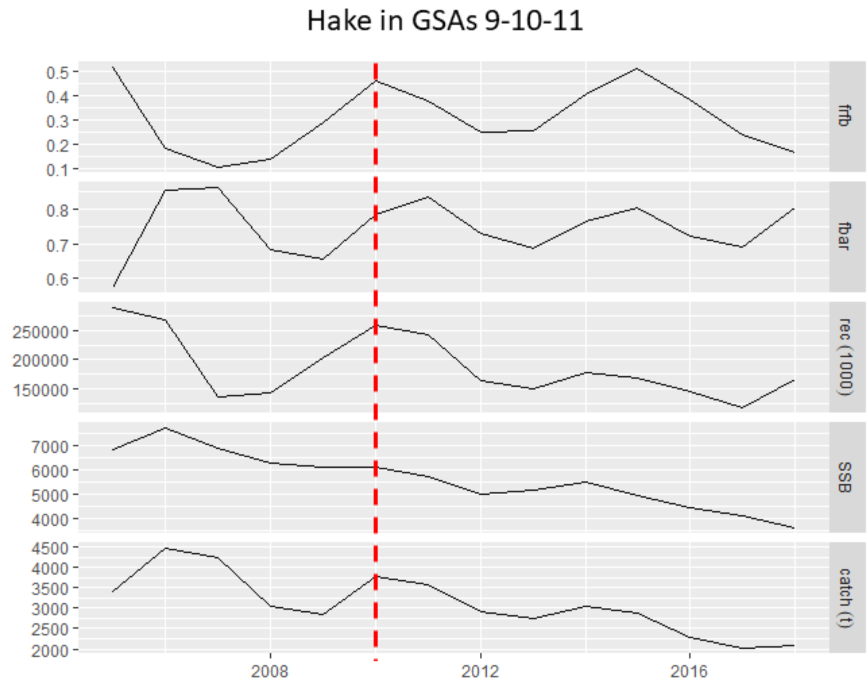

Figure 53. Hake in GSAs 9,10,11. Temporal development of the selectivity indicator (frfb) together with other key stock attributes. frfb: F of first recruited age-class (namely frec, age 0) divided by fbar (age 1-3); fbar: F of the fully exploited age-classes (1-3); rec(1000): recruitment; SSB: spawning-stock biomass; catch(t): catch in tonnes. Red dashed line at year 2010 represents the starting date of the Med Reg [3] implementation.

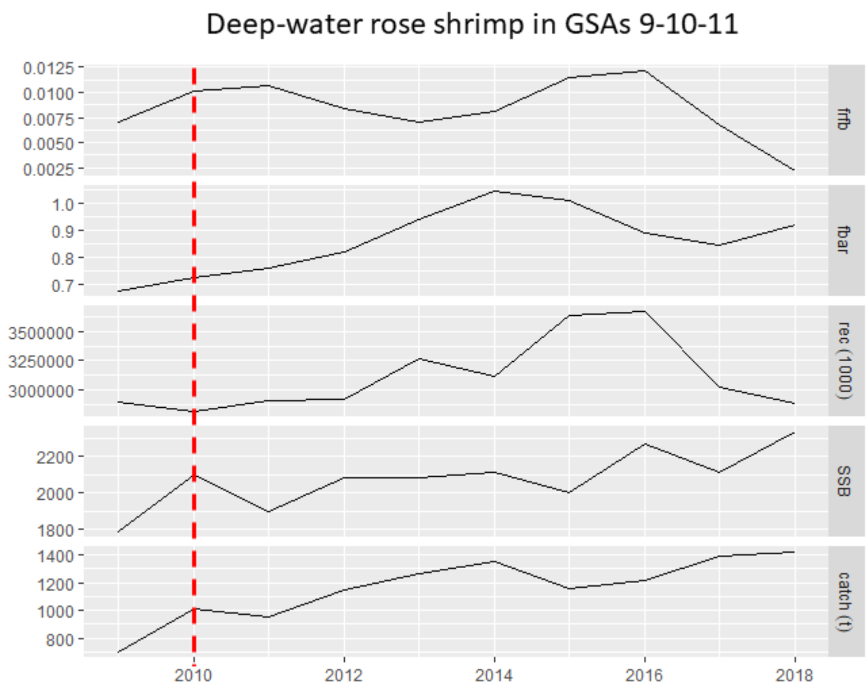

Figure 54. Deep-water rose shrimp in GSAs 9,10,11. Temporal development of the selectivity indicator (frfb) together with other key stock attributes. frfb: F of first

recruited age-class (namely frec, age 0) divided by fbar (age 1-2); fbar: F of the fully exploited age-classes (1-2); rec(1000): recruitment; SSB: spawning-stock biomass; catch(t): catch in tonnes. Red dashed line at year 2010 represents the starting date of the Med Reg [3] implementation.

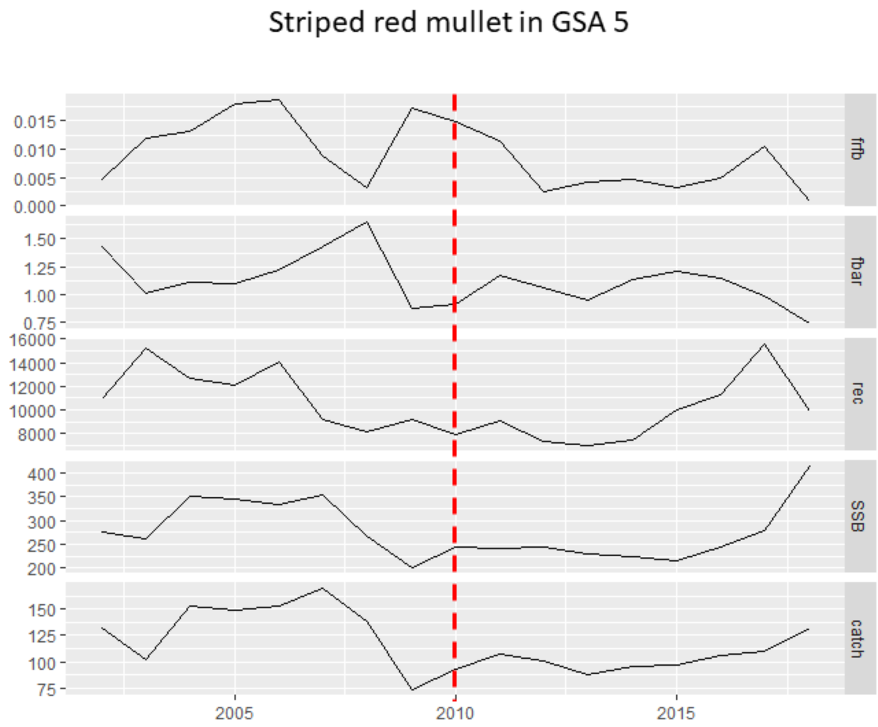

Figure 55. Striped red mullet in GSA 5. Temporal development of the selectivity indicator (frfb) together with other key stock attributes. frfb: F of first recruited age-class (namely frec, age 0) divided by fbar (age 1-3); fbar: F of the fully exploited age-classes (1-3); rec(1000): recruitment; SSB: spawning-stock biomass; catch(t): catch in tonnes. Red dashed line at year 2010 represents the starting date of the Med Reg [3] implementation.

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1. COMMISSION REGULATION (EEC) No 3440/84 of 6 December 1984 on the attachment of devices to trawls, Danish seines and similar nets.

2. Council Regulation (EC) No 1626/94 of 27 June 1994 laying down certain technical measures for the conservation of fishery resources in the Mediterranean.

3. Council Regulation (EC) No 1967/2006 of 21 December 2006 concerning management measures for the sustainable exploitation of fishery resources in the Mediterranean Sea, amending Regulation (EEC) No 2847/93 and repealing Regulation (EC) No 1626/94.

4. Council Regulation (EU) No 1343/2011 of 13 December 2011 on certain provisions for fishing in the GFCM (General Fisheries Commission for the Mediterranean) Agreement area and amending Council Regulation (EC) No 1967/2006 concerning management measures for the sustainable exploitation of fishery resources in the Mediterranean Sea.

5. REGULATION (EU) No 1380/2013 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 11 December 2013 on the Common Fisheries Policy, amending Council Regulations (EC) No 1954/2003 and (EC) No 1224/2009 and repealing Council Regulations (EC) No 2371/2002 and (EC) No 639/2004 and Council Decision 2004/585/EC.

6. REGULATION (EU) 2019/1022 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 20 June 2019 establishing a multiannual plan for the fisheries exploiting demersal stocks in the western Mediterranean Sea and amending Regulation (EU) No 508/2014.

7. REGULATION (EU) 2019/1241 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 20 June 2019 on the conservation of fisheries resources and the protection of marine ecosystems through technical measures, amending Council Regulations (EC) No 1967/2006, (EC) No 1224/2009 and Regulations (EU) No 1380/2013, (EU) 2016/1139, (EU) 2018/973, (EU) 2019/472 and (EU) 2019/1022 of the European Parliament and of the Council, and repealing Council Regulations (EC) No 894/97, (EC) No 850/98, (EC) No 2549/2000, (EC) No 254/2002, (EC) No 812/2004 and (EC) No 2187/2005.

8. Council Regulation (EC) No 1224/2009 of 20 November 2009 establishing a Community control system for ensuring compliance with the rules of the common fisheries policy, amending Regulations (EC) No 847/96, (EC) No 2371/2002, (EC) No 811/2004, (EC) No 768/2005, (EC) No 2115/2005, (EC) No 2166/2005, (EC) No 388/2006, (EC) No 509/2007, (EC) No 676/2007, (EC) No 1098/2007, (EC) No

1300/2008, (EC) No 1342/2008 and repealing Regulations (EEC) No 2847/93, (EC) No 1627/94 and (EC) No 1966/2006.

Management plans under Article 13 of the Med Reg [3]

9. Commission Implementing Regulation (EU) No 1233/2013 of 29 November 2013 establishing a derogation from Regulation (EC) No 1967/2006 as regards the minimum distance from coast and the minimum sea depth for boat seines fishing for transparent and Ferrer's gobies (Aphia minuta and Pseudaphia ferreri) and Lowbody picarel (Spicara smaris) in certain territorial waters of Spain (Balearic Islands).

10. Commission Implementing Regulation (EU) 2019/662 of 25 April 2019 extending the derogation from Council Regulation (EC) No 1967/2006 as regards the minimum distance from coast and the minimum sea depth for boat seines fishing for transparent goby (Aphia minuta), Ferrer's goby (Pseudaphia ferreri) and Lowbody picarel (Spicara smaris) in certain territorial waters of Spain (Balearic Islands).

11. COMMISSION IMPLEMENTING REGULATION (EU) 2020/1243 of 1 September 2020 on extending the derogation from Council Regulation (EC) No 1967/2006 as regards the minimum distance from the coast and the minimum sea depth for boat seines fishing for transparent and Ferrer's gobies (*Aphia minuta* and *Pseudaphia ferreri*) and Lowbody picarel (*Spicara smaris*) in certain territorial waters of Spain (Balearic Islands).

12. Commission Implementing Regulation (EU) No 773/2013 of 12 August 2013 establishing a derogation from Council Regulation (EC) No 1967/2006 as regards the minimum distance from the coast and the minimum sea depth for boat seines fishing for transparent goby (*Aphia minuta*) in certain territorial waters of Spain (Murcia).

13. Commission Implementing Regulation (EU) 2017/677 of 10 April 2017 on extending the derogation from Council Regulation (EC) No 1967/2006 as regards the minimum distance from the coast and depth granted to boat seines fishing for transparent goby (*Aphia minuta*) in certain territorial waters of Spain (Murcia).

14. COMMISSION IMPLEMENTING REGULATION (EU) 2020/1242 of 1 September 2020 extending the derogation from Council Regulation (EC) No 1967/2006 as regards the minimum distance from the coast and depth granted to boat seines fishing for transparent goby (Aphia minuta) within the Spanish territorial waters of the Autonomous Community of the Region of Murcia.

15. Commission Implementing Regulation (EU) No 988/2011 of 4 October 2011 establishing a derogation from Council Regulation (EC) No 1967/2006 as regards the minimum distance from coast and the minimum sea depth for boat seines fishing for transparent goby (*Aphia minuta*) in certain territorial waters of Italy.

16. Commission Implementing Regulation (EU) 2015/2407 of 18 December 2015 renewing the derogation from Council Regulation (EC) No 1967/2006 as regards the minimum distance from coast and the minimum sea depth for boat seines fishing for transparent goby (*Aphia minuta*) in certain territorial waters of Italy.

17. COMMISSION IMPLEMENTING REGULATION (EU) 2018/1634 of 30 October 2018 renewing the derogation from Council Regulation (EC) No 1967/2006 as regards the minimum distance from coast and the minimum sea depth for boat seines fishing for transparent goby (Aphia minuta) in certain territorial waters of Italy.

18. 17. Commission Implementing Regulation (EU) No 464/2014 of 6 May 2014 derogating from Council Regulation (EC) No 1967/2006 as regards the minimum distance from the coast and the minimum sea depth for boat seines fishing for sand eel (Gymnammodytes cicerelus and G. semisquamatus) and gobies (Aphia minuta and Crystalogobius linearis) in certain territorial waters of Spain (Catalonia).

19. COMMISSION IMPLEMENTING REGULATION (EU) 2018/922 of 28 June 2018 derogating from Council Regulation (EC) No 1967/2006 as regards the minimum distance from the coast and the minimum sea depth for boat seines fishing for sand eel (*Gymnammodytes cicerelus* and *G. semisquamatus*) and gobies (*Aphia minuta* and *Crystalogobius linearis*) in certain territorial waters of Spain (Catalonia).

20. Commission Implementing Regulation (EU) No 587/2014 of 2 June 2014 derogating from Council Regulation (EC) No 1967/2006 as regards the minimum distance from the coast and depth for shore seines fishing in certain territorial waters of France (Languedoc-Roussillon and Provence-Alpes-Côte d'Azur).

21. Commission Implementing Regulation (EU) 2015/1421 of 24 August 2015 extending the derogation from Council Regulation (EC) No 1967/2006 as regards the minimum distance from the coast and depth granted to shore seines fishing in certain territorial waters of France (Languedoc-Roussillon and Provence-Alpes-Côte d'Azur).

22. COMMISSION IMPLEMENTING REGULATION (EU) 2018/1596 of 23 October 2018 extending the derogation from Council Regulation (EC) No 1967/2006 as regards the minimum distance from the coast and depth granted to shore seines fishing in certain territorial waters of France (Occitanie and Provence-Alpes-Côte d'Azur).

23. COMMISSION IMPLEMENTING REGULATION (EU) 2018/693 of 7 May 2018 establishing the derogation from Council Regulation (EC) No 1967/2006 as regards the prohibition to fish above protected habitats, the minimum distance from the coast and the minimum sea depth for the 'gangui' trawlers fishing in certain territorial waters of France (Provence-Alpes-Côte d'Azur). *(No longer in force, Date of end of validity: 11/05/2020).*

Landing obligation derogations under article 15 of EU Regulation 1380/2013 [5]

24. COMMISSION DELEGATED REGULATION (EU) 2017/86 of 20 October 2016 establishing a discard plan for certain demersal fisheries in the Mediterranean Sea. (Survivability and De minimis exemption exemption for disproportionate costs of handling unwanted catches). It shall apply from 1 January 2017 to 31 December 2019.

25. COMMISSION DELEGATED REGULATION (EU) 2018/2036 of 18 October 2018 amending Delegated Regulation (EU) 2017/86 establishing a discard plan for certain demersal fisheries in the Mediterranean Sea (Survivability and De minimis exemption exemption).

26. COMMISSION DELEGATED REGULATION (EU) 2020/3 of 28 August 2019 establishing a discard plan for Venus shells (Venus spp.) in certain Italian territorial waters (Survivability exemption for Venus shells (Venus spp.) Minimum conservation reference size).

27. COMMISSION DELEGATED REGULATION (EU) 2020/4 of 29 August 2019 amending Delegated Regulation (EU) 2017/86 establishing a discard plan for certain demersal fisheries in the Mediterranean Sea (Survivability and De minimis exemption exemption).

5. TOR 5 - Estimates of sensitive species by-catch rates

This chapter addresses terms of reference 5: Report on the best available estimates of sensitive species (incl. seabirds, sharks, turtles, cetaceans) disaggregated by species, fishery and Member State in relation to the conservation status of each species with an assessment whether by-catch rates are changing over time and to identify problematic fisheries that may require specific attention.

Article 3(2) in Regulation (EU) 2019/1241 defines the objective to minimise and where possible eliminate incidental catches of sensitive marine species, including those listed under Directives 92/43/EEC [….] that are a result of fishing, so that they do not represent a threat to the conservation status of these species. Article 4 concerning targets goes on to state that bycatches of marine mammals, marine reptiles, seabirds and other non-commercially exploited species do not exceed levels provided for in Union legislation and international agreements that are binding on the Union. In the Directive 2008/56/EC (Marine Strategy Framework Directive) Article 9(1) it is stated that Member States shall, in respect of each marine region or subregion concerned, determine, for the marine waters, a set of characteristics for good environmental status. Bycatch is considered under Descriptor 1, Criteria 1. With the publication of the Commission Decision (EU) 2017/848 of 17 May 2017 assessments of bycatch by Member States are now a requirement against the criteria "The mortality rate per species from incidental by-catch is below levels which threaten the species, such that its long-term viability is ensured."

Hence, to determine specific objectives for each species, it is a requirement to first identify the level posing a threat to the specific species and population, the acceptable level of risk of increasing this level and then evaluate if the bycatch is below this level with the accepted risk. The level posing a threat to a specific population depends on the population size and productivity. Ideally, these levels would be identified together with definitions of GES in the regional analyses for the MSFD. However, to date, no agreed levels to threat and risk to this are available. There has been suggestions to use a single level of bycatch mortality (either directly or relative to natural mortality) but this approach is likely to provide a very poor estimate of the threat level with the added possibility that a common restrictive level is chosen to ensure that that threat to the most sensitive species is avoided. As neither levels presenting a risk nor methods to estimate them are available at present for sensitive species, a stepwise approach was investigated instead:

a. identify sensitive species
b. identify fleets which may pose a threat to sensitive species
c. identify temporal changes in effort of high risk fleets
d. identify examples of technical measures aiming to protect sensitive species
e. identify species where data on population trends of sensitive species, bycatch and/or development in mortality and population status relative to agreed thresholds exist
f. identify species at risk for which insufficient information exist on bycatch rates
g. identify possible steps to remedy data gaps

Definition of sensitive species

Substantial work has been undertaken in later years to reconcile different lists of sensitive species (e.g. in ICES, OSPAR, DGENV, Annex II-III of SPA/BD Protocol of the Barcelona Convention, Appendix I of CITES, Appendix I-II of CMS). In general, there is agreement that all species listed in the Habitats Directive (marine mammals and reptiles and selected species of diadromous fish) should be considered of interest while the situation is slightly less clear for strictly marine fish. For seabirds, the Birds Directive offers a legal framework that protects all species of wild birds in the Union, while species mentioned in Annex I shall benefit of special conservation measures to ensure their survival and reproduction success. The group decided to use lists compiled by WGBYC for seabirds and to use a fish species list from a combination of the lists in the Habitats directive, TAC regulation, IUCN European red list and ICES WGECO to achieve a complete list. For the fish identified by the ICES groups WGECO and WGBIODIV, only species not identified as insensitive by one of the groups were included. All red listed species and species from regulations and directives were included regardless of sensitivity estimated by ICES. The total list of sensitive species can be found in Annex 1.

Fleets which may pose a threat to sensitive species

Several projects and working groups have attempted to identify fleets that pose a risk to specific taxa and species. In general, fish and elasmobranchs are most at vulnerable to towed gear, since this gear type is fairly unselective and by far the most frequently used. Mammals, reptiles and seabirds tend to be most vulnerable to fixed gear, though there are exceptions to this. For seabirds in particular, susceptibility to bycatch in fishing gears is generally related to specific species foraging behaviour. As such, some fishing gears are particularly problematic for some species, while they pose no threats to others. Surface-feeding seabirds are particularly at risk during gear deployment phases. For instance, some species may try to predate on baits on longlines and be hooked, or may collide with trawl cables during gear recovery while feeding on escapes. Diving species forage at depth and are mostly at risk of interacting with set passive gears, e.g., nets, longlines and traps. The group reviewed the fleet risk classification conducted in the Fishpi2[5] and STREAM projects in collaboration with ICES (FISHPI2). The approach combined species (or species group) occurrence, bycatch risk, fishing effort and current monitoring levels by area. High bycatch risk métiers can be identified in different areas, considering different protected species or taxa. Information on high risk métiers in different areas have been categorized for the North Atlantic, the North Sea and the Baltic Sea (table 13).

The approach takes into account the observed effort in métier and area with a purpose to get an overview of areas and métiers in need of monitoring. In this evaluation, we focus on defining the high-risk métiers in different areas as reflected in the summed risk factor. It should be noted that this method identifies gear types posing a risk to several species group but does not identify where one gear is a major threat to a single species. In addition, since the bycatch risk index also is dependent on the fishing effort reported in the area, then in the areas where no effort is reported the risk of bycatch is small. The method to obtain the bycatch risk factor follows these subsequent steps:

1. A general assessment of the risk for a species group to being bycaught in a specific gear type (métier level 4, done by expert judgement);
2. Identification of presence or absence of a species group;
3. Classification of fishing effort for each gear type;
4. Calculation of species and gear specific risk factors (multiplication of 1 to 3);
5. Summation of these index numbers across all species for each gear type (summed bycatch risk factor);

[5] https://datacollection.jrc.ec.europa.eu/documents/10213/1329978/NorthAtlantic+and+NorthSea_fishPi2_MARE-2016-22.pdf/9b83208c-5dab-45b1-b70d-3aa3d99e8db0?version=1.1

*Table 13.Summed risk factors for each métier at different areas (summed across all species). AZ=Azores; BB=Bay of Biscay; CS=Celtic Sea; EA=Eastern Arctic; EB=Eastern Baltic; FI=Faroe Islands; IB=Iberian Sea; IS=Irish Sea; MA=Mid-Atlantic; NS=North Sea and Eastern Channel; SK=Skagerrak and Kattegat; WC=Western Channel; WI=Western Ireland; WS=Western Scotland. The summed risk factor for each métier for the Baltic is taken from WGBYC ICES report 2018. * Set gillnets includes semi-driftnets.*

	AZ	BB	CS	EA	FI	IB	IS	MA	NS	SK	WC	WI	WS	BS
Boat dredge [DRB]	0	27	18	0	0	36	27	0	32	16	36	18	27	NA
Bottom otter trawl [OTB]	0	60	60	36	30	75	60	45	60	48	60	60	60	48
Multi-rig otter trawl [OTT]	0	52	52	0	13	13	13	0	40	30	26	39	39	20
Bottom pair trawl [PTB]	0	39	13	20	13	52	0	0	30	20	13	13	26	36
Beam trawl [TBB]	0	24	36	0	0	48	36	0	36	18	36	12	12	0
Midwater otter trawl [OTM]	0	51	34	45	17	17	34	34	45	30	51	51	51	48
Pelagic pair trawl [PTM]	0	51	34	15	0	34	34	17	45	30	51	51	34	36
Hand and Pole lines [LHP] [LHM]	32	27	27	0	0	36	9	0	24	24	27	18	9	16
Trolling lines [LTL]	0	36	0	0	0	0	0	0	0	0	24	0	0	0
Drifting longlines [LLD]	0	30	15	0	0	45	0	0	0	0	15	30	0	0
Set longlines [LLS]	42	60	45	12	0	60	15	0	36	24	45	60	45	48
Pots and Traps [FPO]	0	44	44	0	0	44	44	22	50	40	44	33	44	52
Fykenets [FYK]	0	45	0	0	0	0	0	0	14	42	0	0	0	72
Stationary uncovered poundnets [FPN]	0	0	0	0	0	0	0	0	0	0	0	0	0	33
Trammelnet [GTR]	0	84	63	0	0	105	21	0	72	54	63	42	21	80
Set gillnet [GNS]	54	84	63	36	21	105	63	0	72	54	84	63	63	110*
Driftnet [GND]	0	75	25	0	0	0	0	0	66	22	50	0	0	0
Purse-seine [PS]	27	30	10	18	0	40	10	0	18	9	20	10	10	16
Lampara nets [LA]	0	0	0	0	0	0	0	0	0	0	0	0	0	NA
Fly shooting seine [SSC]	0	0	22	0	0	0	22	0	30	10	22	22	22	0
Anchored seine [SDN]	0	0	0	0	0	0	11	0	30	30	11	0	0	0
Pair seine [SPR]	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Beach and boat seine [SB] [SV]	0	0	11	0	0	0	0	0	0	20	11	0	0	NA
Glass eel fishing	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Static gears such as GNS, GTR or GND have the highest risk of bycatch in all areas except for Eastern Arctic and Mid-Atlantic. Other gears that pose a high risk of bycatch are bottom otter trawls in all areas, except for the Azores. Mid-water trawls and pelagic trawls have a high risk of bycatch in the Bay of Biscay, Western Channel, Western Ireland and Western Scotland. Also, pots and traps have a relative high bycatch risk in all areas except in the Eastern Arctic, Faroe Islands and Mid-Atlantic. It should be noted that the risk of bycatch is different for different species in different gears. For example, roundfish have a higher risk of bycatch in bottom otter-trawls than dolphins and porpoises. In table 14, the risk of bycatch has been categorized for different taxa in different métiers. The potential risk for bycatch is based on expert judgement.

Table 14. Identified risk (by expert opinion) for species groups by each fishing gear. 1: low risk, 2: medium risk, 3: high risk. From 1.

GEAR	LAMPREYS	ROUND FISH	TURTLES	DIVING BIRDS	SURFACE BIRDS	SEALS	DOLPHINS	HARBOUR PORPOISE	LARGE WHALES
Boat dredge [DRB]	1	1	1	1	1	1	1	1	1
Bottom otter trawl [OTB]	2	2	3	1	2	2	1	1	1
Multi-rig otter trawl [OTT]	2	2	3	1	1	1	1	1	1
Bottom pair trawl [PTB]	2	2	3	1	1	1	1	1	1
Beam trawl [TBB]	2	1	3	1	1	1	1	1	1
Midwater otter trawl [OTM]	1	3	2	2	2	2	2	1	2
Pelagic pair trawl [PTM]	1	3	2	2	2	2	2	1	2
Hand and Pole lines [LHP] [LHM]	1	1	1	1	1	1	1	1	1
Trolling lines [LTL]	1	1	1	2	3	1	1	1	1
Drifting longlines [LLD]	1	1	3	2	3	1	1	1	2
Set longlines [LLS]	1	1	3	2	3	1	1	1	2
Pots and Traps [FPO]	2	1	1	1	1	1	1	1	2
Fykenets [FYK]	3	2	1	2	1	3	1	1	1
Stationary uncovered poundnets [FPN]	1	1	1	1	1	2	1	1	1
Trammelnet [GTR]	1	3	3	3	1	3	2	3	2
Set gillnet [GNS]	1	3	3	3	1	3	2	3	2
Driftnet [GND]	1	3	3	3	3	3	3	3	3
Purse-seine [PS]	1	1	1	1	1	1	2	1	1
Lampara nets [LA]	1	1	1	1	1	1	1	1	1
Fly shooting seine [SSC]	2	2	1	1	1	1	1	1	1
Anchored seine [SDN]	2	2	1	1	1	1	1	1	1
Pair seine [SPR]	2	2	1	1	1	1	1	1	1
Beach and boat seine [SB] [SV]	2	2	1	1	1	1	1	1	1
Glass eel fishing	2	1	1	1	1	1	1	1	1

In total, the top 5 risk gears for each area are seen in Table 15.

Table 15: Top 5 risk gear types. Note that this method identifies gear types posing a risk to several species group but does not identify where one gear is a major threat to a single species. 5 is the gear posing the greatest risk. AZ=Azores; BB=Bay of Biscay; CS=Celtic Sea; EA=Eastern Arctic; EB=Eastern Baltic; FI=Faroe Islands; IB=Iberian Sea; IS=Irish Sea; MA=Mid-Atlantic; NS=North Sea and Eastern Channel; SK=Skagerrak and Kattegat; WB =Western Baltic; WC=Western Channel; WI=Western Ireland; WS=Western Scotland. Set gillnets include semi-driftnets. From1

	AZ	BB	CS	EA	FI	IB	IS	MA	NS	SK	WC	WI	WS	BS	Total score
Boat dredge [DRB]															0
Bottom otter trawl [OTB]		2	3			3	4		2		3	4	4		25
Multi-rig otter trawl [OTT]			2												2
Bottom pair trawl [PTB]						1									1
Beam trawl [TBB]															0
Midwater otter trawl [OTM]											2	2	3		7
Pelagic pair trawl [PTM]											2	2			4
Hand and Pole lines [LHP] [LHM]	3														3
Trolling lines [LTL]															0
Drifting longlines [LLD]															0
Set longlines [LLS]	5	2				2						4			13
Pots and Traps [FPO]									1					2	3
Fykenets [FYK]														3	3
Stationary uncovered poundnets [FPN]															0
Trammelnet [GTR]		5	5			5			5	5	4			4	33
Set gillnet [GNS]	5	5	5			5	5		5	5	5	5	5	5	55
Driftnet [GND]		3							3						6
Purse-seine [PS]	2														2
Lampara nets [LA]															0
Fly shooting seine [SSC]															0
Anchored seine [SDN]															0
Pair seine [SPR]	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA			NA
Beach and boat seine [SB] [SV]															0
Glass eel fishing	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA			NA

No similar evaluation exists for the Mediterranean Sea. However, the general conclusion of the highest risk gear being bottom otter trawl, midwater otter trawl, set longlines, trammel net and set gillnets in the other areas is assumed to be valid for the Mediterranean region.

The analysis above reveals fleets that may pose a risk to a collection of bycaught species. However, more species-specific investigations are performed by ICES WGBYC for a selection of species. ICES WGBYC collects observer data on bycatch of vulnerable species through DCF sampling programs, as well as through dedicated monitoring under regulation 812/2004 (now repealed). Bycatch events for marine mammals are relatively rare, therefore, in WGBYC 2019 data in the WGBYC database for 2005–2017 were compiled over several years in different areas to be able to get more reliable confidence intervals of the bycatch rates. Marine mammals that were included in the summary were: common dolphin (*Delphinus delphis*), grey seal, harbor porpoise, white beaked dolphin (*Lagenorhynchus albirostris*), Atlantic white-sided dolphin (*Lagenorhynchus acutus)*, striped dolphin (*Stenella coeruleoalba*), "seals" (*Phocidae*), harbor seal (*Phoca vitulina*), bottlenose dolphin (*Tursiops truncatus*) and long-finned pilot whale (*Globicephala melas*). Métier-specific minimum and maximum bycatch rates were estimated for different métiers. The numbers of bycaught animals differ significantly over the years in certain areas and/or métiers, possibly as a result of variations in fishing effort, species distribution and abundance. The rates presented in table 16 indicate the relative risk of bycatch across métiers and ecoregions. Bycatch rates for common dolphins in midwater trawls in the eastern Bay of Biscay shelf are high. The bycatch rates based on observed monitored data confirm the expert judgement approach presented above, resulting in high bycatch rates for all observed bycaught species and in all areas in set net fisheries.

Table 16: Observed DaS, number of individuals and bycatch rates (individuals per day at sea) for marine mammal species, pooled by métier described and by area using data pooled over different time periods between 2005 until 2017 and held within the WGBYC database. Bycatch rate = specimens/DaS observed. Table presented in the ICES WGBYC 2019 (ICES 2019).

Ecoregion	Metier L4	Years pooled	DaysAtSea Observed	Marine mammal Species	Specimens	Low bycatch rate (95% CI)	High bycatch rate (95% CI)
North Sea	GNS, GTR, GND	2008-2017	3402.15	*Delphinus delphis*	14	0.0022	0.0069
				Halichoerus grypus	8	0.0012	0.0042
				Phoca vitulina	2	0.0001	0.0018
				Phocoena phocoena	118	0.0297	0.0403
				Stenella coeruleoalba	2	0.0001	0.0018
				Tursiops truncatos	2	0.0001	0.0018
				Lagenorhynchus acutus	1	1.5077E-05	0.0014
				Lagenorhynchus albirostris	1	1.5077E-05	0.0014
	PTM. OTM	2008-2017	1783.77	*Delphinus delphis*	59	0.0252	0.0427

				Phoca vitulina	5	0.0011	0.0059
				Phocoena phocoena	1	2.8751E-05	0.0027
				Tursiops truncatos	5	0.0011	0.0059
	OTB. OTT. PBT	2010-2017	2883	*Delphinus delphis*	3	0.0002	0.0030
				Phocidae	1	1.7791E-05	0.0016
Celtic Sea	GNS. GTR	2005-2017	1720.37	*Delphinus delphis*	27	0.0103	0.0228
				Halichoerus grypus	85	0.0411	0.0589
				Phoca vitulina	12	0.0040	0.0113
				Phocoena phocoena	119	0.0594	0.0801
				Globicephala melas	2	0.0002	0.0036
				Phocidae	2	0.0002	0.0036
	PTM. OTM	2007-2017	1449	*Delphinus delphis*	41	0.0203	0.0384
				Halichoerus grypus	13	0.0053	0.0142
				Globicephala melas	6	0.0018	0.0082
				Lagenorhynchus albirostris	1	0.00003	0.0033
	OTB. OTT.	2016-2017	1945.58	*Delphinus delphis*	5	0.0008	0.006
				Halichoerus grypus	60	0.0247	0.0381
				Phocoena phocoena	2	0.0002	0.0032
				Stenella coeruleoalba	1	2.6358E-05	0.0024
				Phocidae	1	2.6358E-05	0.0024
Eastern Biscay Shelf (8a and b)	GNS. GTR. GND*	2008-2017	2558.82	*Delphinus delphis*	48	0.0138	0.0249
				Halichoerus grypus	8	0.0015	0.0056
				Phoca vitulina	1	2.0044E-05	0.0018
				Phocoena phocoena	26	0.0071	0.0141
				Stenella coeruleoalba	4	0.0005	0.0036
	PTM. OTM	2008-2017	686.42	*Delphinus delphis*	224	0.285	0.372

			Phocoena phocoena	2	0.0005	0.0094
OTB. OTT. PTB	2017	198.18	*Halichoerus grypus*	1	0.0003	0.0237
			Phocoena phocoena	1	0.0003	0.0237

***No observer effort in metier GND, only fishing effort in GND.**

The Joint OSPAR/HELCOM/ICES Expert Group on Seabirds (JWGBIRD) collated information on evidence of the sensitivity/vulnerability of marine bird species and families to bycatch in fishing gears (ICES, 2018). This work identified shearwaters, sulids, cormorants, gulls, ducks, auks, petrels and fulmar, storm petrels, grebes, phalaropes, terns and skuas, as having been recorded as bycatch in EU fisheries. Métiers with registered bycatch included purse seine (PS), midwater otter and midwater pair trawls (OTM/PTM), beam, bottom otter, multi-rig otter and bottom pair trawls (TBB/ OTB/OTT/PTB), trammel-, set- and drift-nets (GN), set and drifting longlines (LL), and pots and traps (FPO). ICES WGBYC compiled seabird bycatch data for the year 2017, summarized in Table 17. The species and fisheries presented in this table were selected based both on the conservation concern of the species (e.g., the Balearic shearwater), and/or on the quantity of data for a particular species, regardless of its conservation status (e.g., the great cormorant). To address the question of uncertainty, the bycatch rates are presented as the 95% bootstrapped confidence intervals around mean bycatch rates (as the number of individual of a species per day at sea in the selected fisheries).

Table 17: Bycatch rates (individuals per day at sea) for selected seabird species, areas and gears, following WGBYC data call and based on data from 2017. In order to obtain reasonable observed effort, a number of months or areas were combined. One country uploaded decimals for observed days at sea. Table presented in the ICES WGBYC 2019 report (ICES 2019).

Month	AreaCode	MetierL4	DaysAtSea Observed	Species	Specimen	Incidents	Low bycatch rate (95% CI)	High bycatch rate (95% CI)
3,4,6,7	27.5.a.2	GNS	126	*Cepphus grylle*	20	6	0.10	0.25
3	27.5.a.2	GNS	43	*Clangula hyemalis*	2	2	0.01	0.17
4	27.5.a.2	GNS	74	*Fulmarus glacialis*	3	2	0.01	0.12
1,2,3,5,7,10	27.5.a.2	LLS	89	*Fulmarus glacialis*	69	9	0.60	0.98
4,5,6	GFCM 1~5~6	LLD	39	*Larus audouinii*	5	3	0.04	0.30
4	27.5.a.2	GNS	74	*Morus bassanus*	3	3	0.01	0.12
5	27.5.a.2	LLS	23	*Morus bassanus*	24	3	0.67	1.55
6	27.4.a	OTB,PTB	151	*Morus bassanus*	16	6	0.06	0.17
3,6,7	27.5.a.2	GNS	52	*Phalacrocoracidae*	10	6	0.09	0.35
4 to 11	27.3.d.29,30, 32	GNS	36	*Phalacrocorax carbo*	49	21	1.01	1.80

7,8	27.8.b	GNS,GTR	8	*Puffinus mauretanicus*	4	2	0.14	1.27
5,8	GFCM 1~5~6	LLD	107	*Puffinus mauretanicus*	3	3	0.01	0.08
4,5,10	27.3.d.29,30	GNS	14	*Somateria mollissima*	19	5	0.82	2.12
3 to 7	27.5.a.2	GNS	131	*Somateria mollissima*	62	13	0.36	0.61
1,2,3,5, 10,11,12	27.7e,f,j	GNS	57	*Uria aalge*	14	11	0.14	0.42
11	27.8a,b	GNS	14	*Uria aalge*	6	4	0.15	0.90
3 to 5	27.5.a.2	GNS	122	*Uria aalge*	55	13	0.34	0.59

Temporal changes in effort of high risk fleets

Time series of fishing effort data for static gears are notoriously difficult to obtain. Hence, long time series were derived from commercial fishing effort data, assuming that the average fishing pressure relative to FMSY reflects commercial fishing effort. This allowed the production of longer time series from FDI data and other sources.

Fishing Effort per MS and fleet-segment is annually collected via FDI (STECF Fisheries Dependent Indicator) EU data call. Detailed information about the data requested in the context of the FDI data call is available on the DCF website https://datacollection.jrc.ec.europa.eu/data-calls. Information about the quality of the data can be found in the report from the STECF EWG 19-11 available at https://stecf.jrc.ec.europa.eu/reports/fdi. The collection also includes small fleet-segments not equipped with VMS onboard (i.e. <12m) that could help to inform effective fishing effort (and not only days at sea) for small-scale fishing vessels, mainly gillnetters, and eventually to compute bycatch rates per unit of fishing effort for a given species and area. A common issue is that the fishing effort is declared per days (the requirement of the control regulation is a daily logbook entry if the area and gear stay the same) and not per effective hours at fishing. Therefore, the FDI group or the Member States apply some assumption to build back the "days at sea" that are differentiated from the "fishing days". The calculation procedure has been recently standardized, and the new-FDI database is storing this information (Table FDI-effort-by-country.xlsx) as documented in Appendix 15 of the STECF new-FDI 2017 report. This is still not giving hours at fishing because this would require declaration per haul that is optional and not available for most of the segment. Analysing the effort extracted from FDI from the past four years indicate that fishing effort is stable for all gears and in all areas except for the Baltic gillnets, which has decreased substantially over the past years (Figure 56). Gillnets constitutes the main fishing effort in terms of DaS in the Baltic and the main decrease the past four years was seen in German, Estonian and Polish gillnet fleets (Figure 57). ICES WGBYC analysed the gillnet fishing effort from 2009 until 2018 in the Baltic and found that gillnet fishing effort has decreased by 44% over the past 10 years. In 2019, gillnet effort for cod has decreased even more since August 2019 in the southern Baltic due to the implementation of the EU Regulations 2019/1248 and 2019/183, closing gillnet fisheries for cod in waters deeper than 20 metres in ICES Subdivision 24, and in all gillnet fisheries for cod in Subdivisions 25–32 (ICES WKEMBYC). Trawl fisheries targeting cod in the area were also affected.

According to the FDI data for the Mediterranean Sea, the fishing effort in the Western Mediterranean for all gears decreased over the past four years. In contrast, effort gradually increased in the Adriatic Sea (by almost 15% during 2015-2018) for bottom trawls, longlines and traps, whereas it was stable for the rest of gears. In Ionian and Central Mediterranean and Aegean ecoregions fishing effort was remained almost stable during 2015-2018. In the Black sea fishing effort substantially increased (by approximately 46%) for bottom trawls, whereas it remained stable for the rest gears (Figure 58).

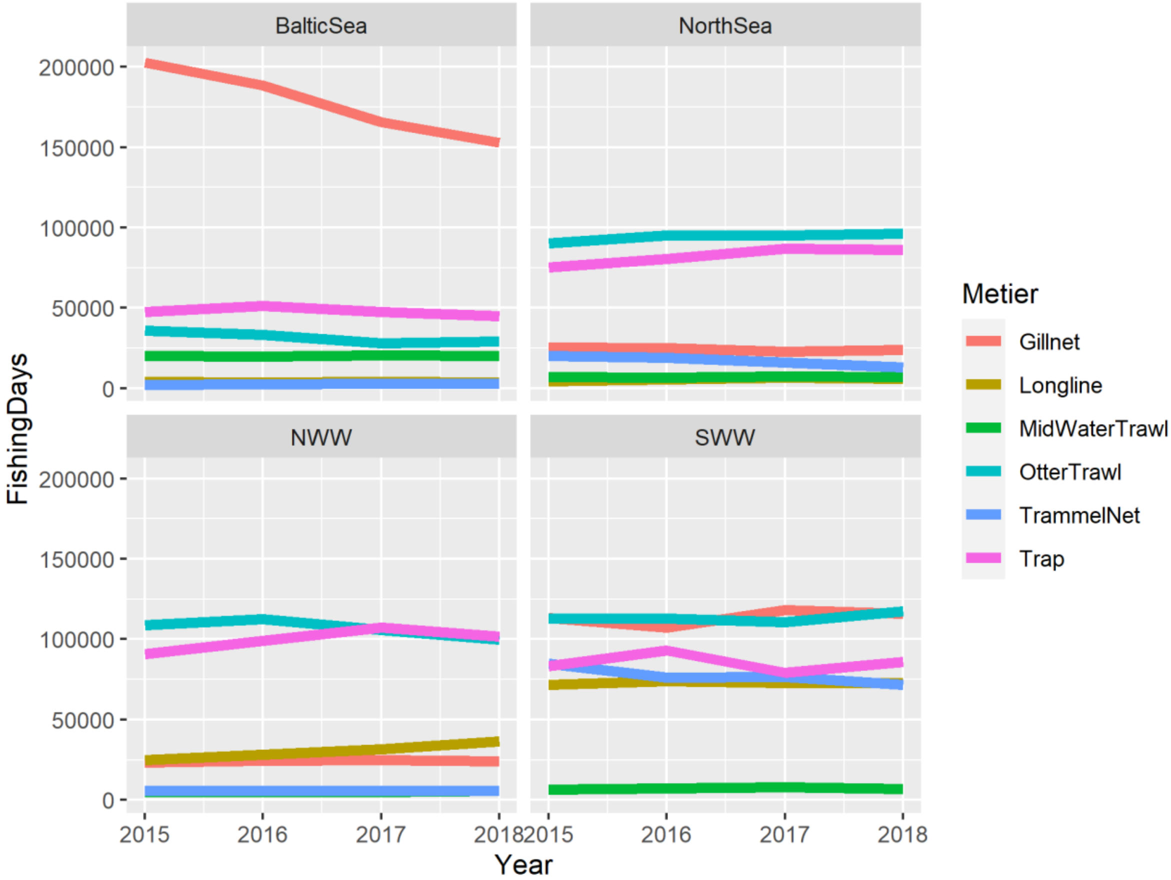

Figure 56: Fishing Days per metier level 3 and ecoregion extracted from the FDI database (effort_per_country.xls) for the period 2015-2018 ('new-FDI' data).

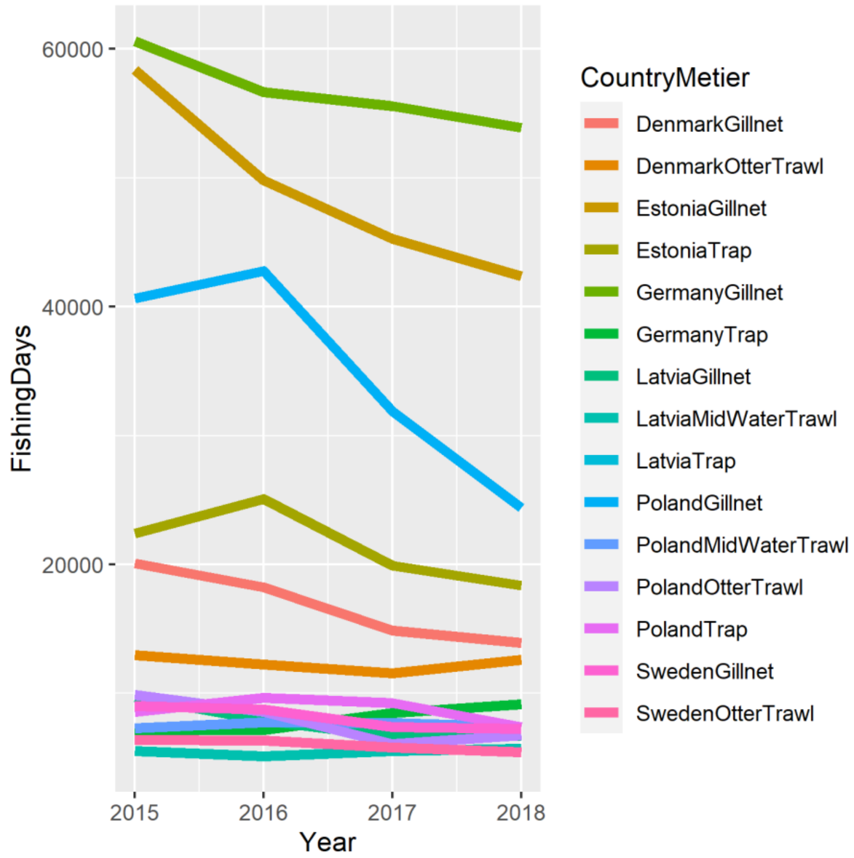

Figure 57: Fishing Days in the Baltic Sea ecoregion per metier level 3 combined to country name extracted from the 2020 FDI database (effort_per_country.xls) for the period 2015-2018 ('new-FDI' data).

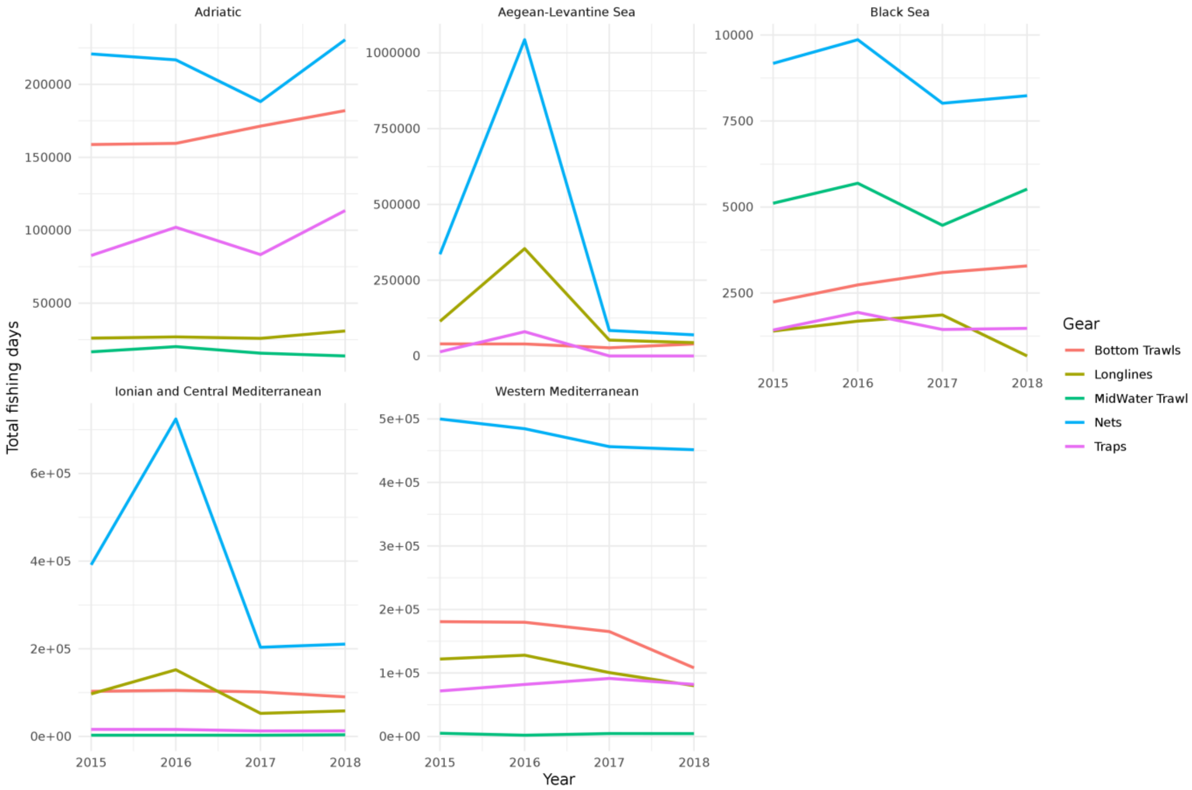

Figure 58: Fishing Days in the Mediterranean Sea per major areas per metier level 3 combined to country name extracted from the 2020 FDI database (effort_per_country.xls) for the period 2015-2018 ('new-FDI' data). (note that fishing days data for Aegean-Levantine Sea from bottom trawls were derived from WGBYC, ICES 2020).

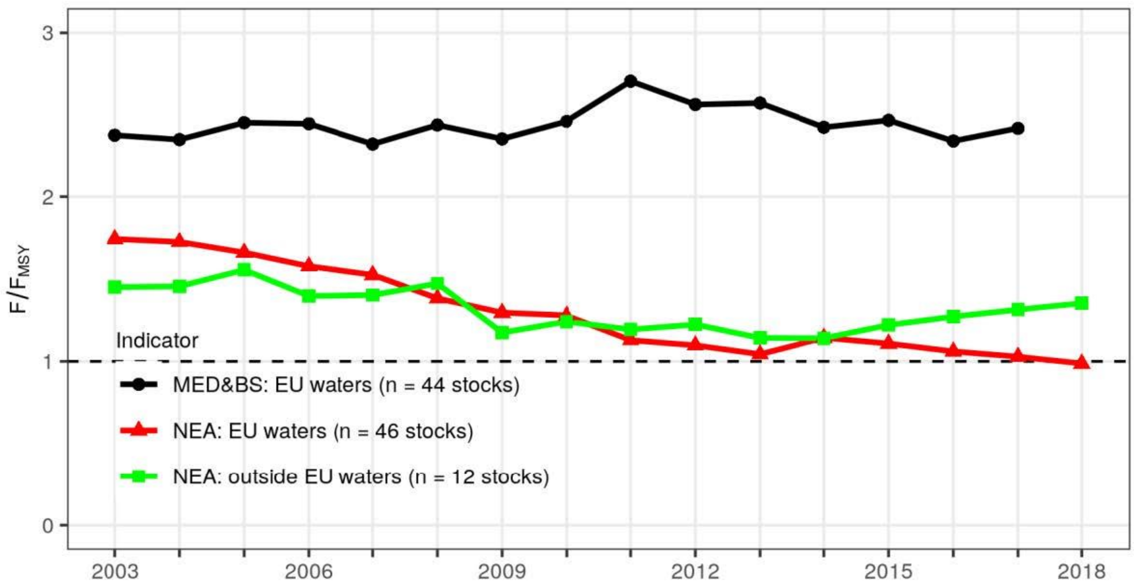

Figure 59: Trends in fishing pressure 2003-2018. Three model based indicators F/FMSY are presented (all referring to the median value of the model): one for 46 EU stocks with appropriate information in the NE Atlantic (red line); one for an additional set of 12 stocks also located in the NE Atlantic but outside EU waters (green line), and one for the 44 assessed stocks from the Mediterranean & Black Seas (black line) (extracted from

STECF-20-01 Monitoring the performance of the CFP). The dotted black line shows when average fishing mortality is the same as the maximum sustainable yield.

Data from STECF shows a decline in Northeast Atlantic European waters in the total fishing pressures as F/FMSY, meaning the ratio of actual fishing mortality (F) to the level that would provide maximum sustainable yield (FMSY) from 2003 until 2018. In the Mediterranean and in the Black Seas there is no decrease in fishing pressure over the 14-year period. In the NE Atlantic, there is a decreasing trend in fishing pressure.

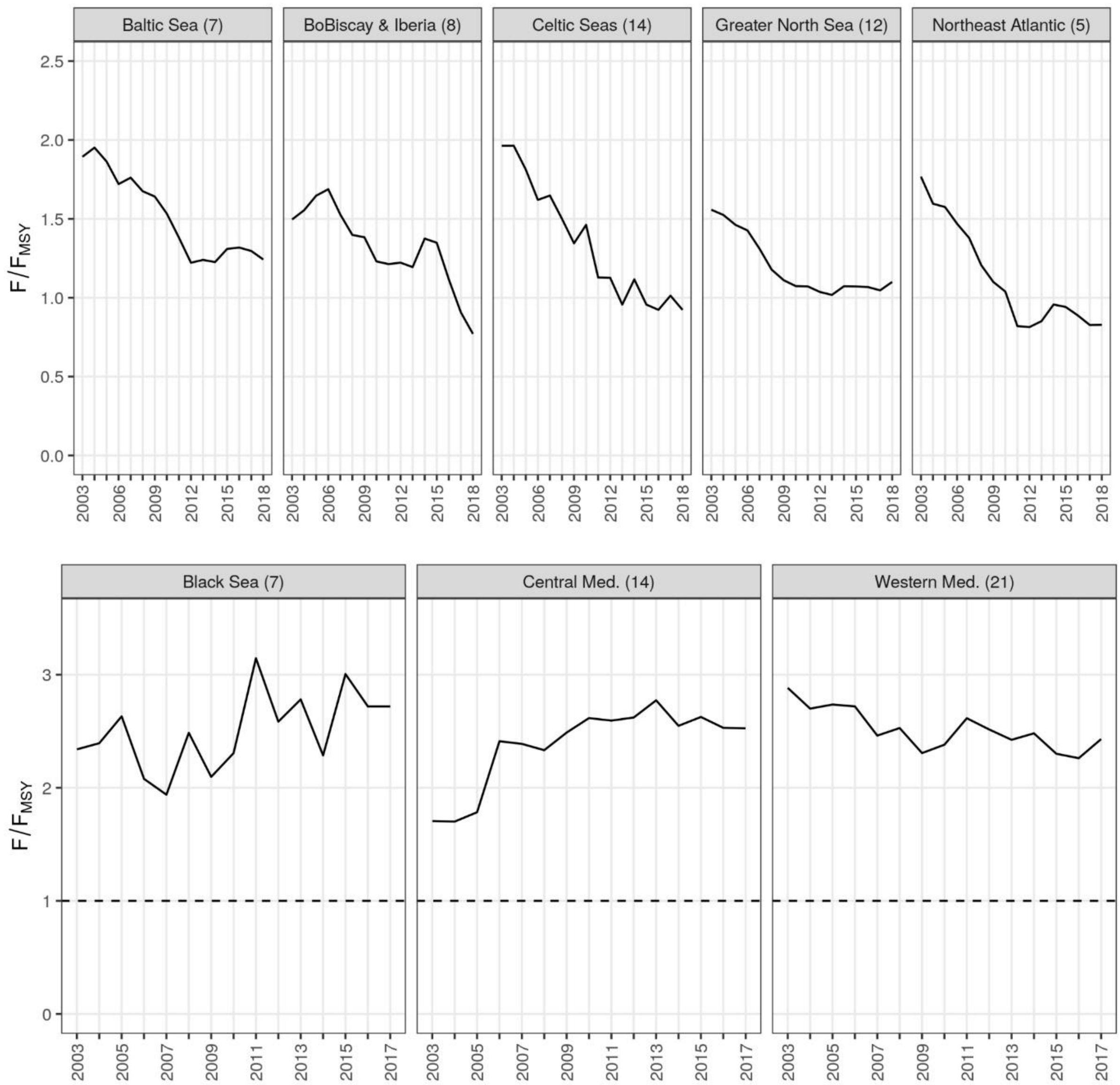

Figure 60: Trend in F/FMSY by ecoregion in FAO 27. The number of stocks in each ecoregion is shown between parentheses (extracted from STECF-20-01 Monitoring the performance of the CFP). Due to the low number of stocks available for the Eastern Mediterranean, the indicator is not shown.

Data on fishing pressure (F/Fmsy) from STECF analysed by region from 2003 until 2018 indicate a decrease in fishing pressure from 2003 until around 2012 in the Baltic Sea, Celtic Sea and Greater North Sea. From 2012 until 2018 the fishing pressure in these regions has been relatively stable. In the Bay of Biscay, the fishing pressure decreased from 2012 until 2018 (Figure 59 and 60).

Similar data from ICES show that the demersal and benthic fishing pressure (mostly trawl pressure) in the Northeast Atlantic increased steadily until around 2000 after which it declined to less than half its previous level (ICES fisheries overviews 2019). Pelagic fishing pressure also declined, though the magnitude of the decline was less.

Bycatch risk of species is not only dependent on the fishing effort, but also on the spatial distribution of the species and fisheries in the area and on the métier distribution of effort. Therefore, assessing changes in bycatch risk based on fishing effort can cause misinterpretation. Nevertheless, since the decline in fishing effort in the Northeast Atlantic is large, tentative conclusions can still be made. **The overall conclusion is that since fishing effort in the Northeast Atlantic the past 10 years has decreased, so has the bycatch risk of marine mammals, birds, fish and turtles. Since the Baltic is an area with high gillnet fishing effort and this is a métier with a high risk of bycatch, it is likely that bycatch of marine mammals, birds and fish has also decreased in this area. The change in the Mediterranean Sea over the past 15 years is either, increasing (Black Sea), at best minor (Adriatic Sea) and in the remaining areas non existent. Hence, it seems unlikely that there has been major declines in bycatch risks in these areas.** It should be noted that in many countries the fishing effort of small vessels mainly fishing with the high-risk métier GNS and GTR is not reported and, therefore, might not be included in the general overview of fishing pressures. If the gillnet fisheries in other areas than the Baltic have increased, then this will affect the overall bycatch mortality in the areas.

Although there are common standards of recording fishing effort across Member States and in central databases (e.g. the ICES Regional Database [RDB]), the Mediterranean data, especially for the Eastern Mediterranean, do not have a unit of effort that is compatible with the bycatch monitoring data. The latter currently uses "days at sea" but this is not submitted routinely in the fishing effort data by all Member States, as it is not a mandatory requirement of data submission to the ICES RDB.

Examples of technical measures aiming to protect sensitive species

During the last decade, various projects, mostly on sea turtles (i.e., LifeEuroTurtles and TartaLife), and to a much lesser extent on elasmobranchs (i.e., SHARKLIFE) have been implemented in Western and Central Mediterranean (Italian waters) Seas through LIFE. In the course of these projects, in the Northern and Central Adriatic Sea, an extensive monitoring program on incidental catches and mitigation efforts of reducing the captures of the marine megafauna (i.e., cetaceans, sea turtles and elasmobranchs) has been conducted.

Acoustic deterrents (Pingers, Acoustic Harassment Devices, Predator sounds and Passive acoustic deterrents) can serve as an effective bycatch reduction measure in certain areas and for some marine mammal species. Passive acoustic deterrents are inexpensive and easy to implement. However, there is yet no conclusive evidence of their effectiveness for reducing cetacean bycatch mortality at fleet level. In European waters, where EU legislation requires the use of pingers to minimise harbour porpoise bycatch in certain fisheries, studies to test the robustness and practicality of pingers in fishing operations show significant operational problems (durability and functionality of the devices) with failure rates exceeded 50% for some pinger types. Fewer operational issues are encountered with small-scale vessels (Lunneryd 2006).

North Atlantic *Eubalaena glacialis* (Nowacek, 2004) and *Megaptera novaeangliae* showed a behavioural response to high frequency sound exposure or pinger sounds (Harcourt et al., 2014; Pirotta et al., 2016), but there is no evidence that this type of reaction will help prevent entanglements in fishing gear. Bottlenose dolphins (*Tursiops truncatus*) are attracted to the sound of pingers, because they associate the sound with easy-to-catch fish caught in gillnets ("dinner bell", Cox et al., 2004; Leeney et al., 2007). There is no indication that pingers deter bottlenose dolphins from entering trawl nets (Allen et al., 2014). Predator sounds have shown some potential for deterring particular marine mammal species (Werner et al., 2015), but they can also affect the behaviour of target fish, leading to reduced target catch (Doksæter et al., 2009).

The regulation 812/2004 calls for implementing pingers for vessels with an overall length of 12 meters. The regulation is now repealed, however, ICES WGBYC (2019) provides a summary of the status of pinger implementation according the Regulation and status of other studies on mitigation by country. Of all the submitted Reg. 812/2004 reports in 2018, it appears that in only one Member State, pinger use is fully implemented with active regulation enforcement. In some countries, monitoring of the implementation of pingers as per the regulation Annex I is limited and the degree of compliance is unknown. Sweden started a large scale project in 2015 with the purpose of implementing pingers on a voluntary basis in areas and fisheries with a high risk of bycatch. In Italy and Portugal, pingers are implemented on a voluntary basis, and additional monitoring about their effectiveness in reducing bycatch of dolphins is carried out. In France, pingers are used on a voluntary basis only, without monitoring. There are a number of EU countries, whose fleets are not covered by the regulation entirely (see Table 18) or the size of the vessels and/or the regions where the fishery takes place (e.g. Germany). In non-EU countries, like Iceland and Norway, pingers are tested to reduce the bycatch of small cetaceans, with mixed results. For example, in Iceland two different pingers (banana pingers and PALs) showed no effect in reducing the bycatch of harbour porpoises. Sweden has been using banana pingers with promising results. In the coastal gillnet fisheries in the southern and eastern Baltic Sea by Polish and Lithuanian institutes, mitigation methods using LED lights (green, white and flashing white) fixed at regular intervals on the float line, as well as high-contrast panels attached to the gillnet panels were investigated, but both failed to reduce seabird bycatch significantly (Field et al., 2019). Similar trials were conducted with LED lights and low frequency pingers in Denmark, but the low number of seabird bycatches registered did not allow to conclude of the effect (or absence of effect) of these devices (unpublished data). Nevertheless, other studies in small-scale gillnet fisheries outside the EU have reported positive results using LED lights to reduce the bycatch of at least one species of seabirds (Mangel et al., 2018).

Table 18: From ICES WGBYC 2018. Summary of mitigation requirements in relation to Regulation 812/2004. The information is from the 2016 Reg. 812/2004 annual reports and additional information on mitigation submitted to WGBYC from Member States. Although Member States have reported that mandatory pinger use is being implemented, of all the submitted Reg. 812/2004 reports, only in the UK is pinger use fully implemented with active enforcement.

Country	**Pinger use obligatory under Reg 812/2004**	**Mandatory pinger use implemented**	**Other pinger trials**	**Information about other mitigation trials**
Denmark	YES	YES	YES	YES
Estonia	NO	-	NO	NO
France	YES	YES	NO	NO
Germany	YES	YES	YES	NO
Iceland	NO	-	YES	NO

Ireland	YES	No information	NO	NO
Italy	NO	-	YES	NO
Latvia	NO	-	NO	NO
Lithuania	NO Report			
Norway (Info from WGMME report)	NO	-	YES	NO
Netherlands	YES	Not known	NO	NO
Poland	YES	YES	NO	NO
Portugal	NO	-	YES	NO
Slovenia	NO	-	-	NO
Spain	NO	-	NO	NO
Sweden	YES	NO	YES	YES
UK	YES	YES	NO	NO
USA	NO	-	NO	YES

Marine mammal excluder devices follow the same principle than turtle excluder devices (TEDs) (FAO, 2020). Studies testing this device provide mixed results showing that although some dolphin escape from the gear, there is some mortality, and often the tail remains stuck in the excluder device (Wakefield et al. 2017; Santana-Garcon et al., 2018).

Lighting of gillnets has been shown to reduce bycatch of susceptible taxa in some fisheries outside the EU (Ortiz et al., 2016; Mangel et al., 2018; Bieli et al., 2020), but experiments in the Mediterranean (Balearic lobster fishery and French artisanal gillnets) and in the Baltic Sea have not been conclusive (Virgili et al., 2017; Field et al., 2019). Modern artificial baits on bottom longlines can have a negative effect with deeper hooking due to elasticity of bait (Baez et al., 2014, Piovano et al., 2017). Circle hooks do also have an effect on bycatch rates and have reduced bycatch rates without negatively affecting tuna fisheries. For instance, swordfish catch is reduced in surface longlines equipped with circle hooks as opposed to "J" hooks (Swimmer et al., 2017) and the proportion of undersized swordfish caught is reduced (Tserpes et al., 2020).

Different technological mitigation measures for avoiding turtle bycatches (e.g., TED and UV-LED lamps) have been tested in the Mediterranean and they seem to be effective in multispecies fisheries in critical areas and seasons (Sala et al., 2011; Lucchetti et al., 2016a,b, 2019). For the Adriatic Sea, Lucchetti et al. (2019) showed that the use of TEDs reduced bycatch but did not affect the commercial catch. Likewise, modified TEDs in Turkish waters (Atabey and Taskavak 2001) showed that both *Caretta caretta* and *Chelonia mydas* were excluded from the catch, as well as unwanted incidental catches of jellyfish, sharks, and rays. For the Adriatic Sea, Virgili et al. (2018) observed a bycatch reduction of 100%, using UV light in bottom set-gillnet fisheries in deep waters (>70 m), while the efficiency of commercial catch was maintained. For seabirds, Annex XIII of the Regulation (EU) 2019/1241mentions the mandatory use of "bird scaring lines and/or weighted lines, if it is scientifically proven that such use has a conservation benefit in the area, and where practical and beneficial shall set longlines during the hours of darkness with the minimum of deck lighting necessary for safety", following the recommendation GFCM/35/2011/3. In Spain, for instance, the use of tori lines in longlines fisheries is mandatory in order to mitigate the bycatch of birds and sea turtles (Article 19 of the Regulation AAA/ 658/2014).

With respect to the mitigation efforts on the incidental catches of elasmobranchs the use of monofilament snoods, which sharks can more easily cut, seems preferable to other types of braided synthetic fiber or steel (Abella et al., 2005). In contrast, the use of circle hooks increase shark catches and specimen size, while facilitating the release of the sharks caught (Bradai et al., 2018).

In conclusion, although there are many alternatives for reducing bycatch of sensitive marine species, most of them require evaluation per métier used and area of operation. Progress in mitigation of bycatch seems to have been inconsistent and ambiguous. For example, pinger effectiveness seems to vary between area and fishing métier. Further development of mitigation measures, as well as trials to test their effectiveness, are needed to reduce the bycatch of protected species in many fisheries. In addition, in identified high risk areas and fisheries the introduction of an approach similar to the USA's Bycatch Reduction Plans is suggested. This approach outline a mixture of measures, involving all relevant stakeholders, such as the use of more selective gears, area closures, real-time closures, avoidance measures and move-on rules that could be implemented to reduce bycatch. In the EU, such plans could be developed within the context of the Regional Advisory Groups with the aid through ASCOBANS, ACCOBAMS and similar agreements to reduce bycatch.

Species/fleet combinations where data on bycatch exist

Mammals

Full scale assessments of all species and all areas have not been made in European waters. However, ICES WGBYC compiles data on bycatch rates and effort and for certain areas and species it is possible to give a relative assessment of the bycatch mortality. In this chapter, a compilation of the assessments carried out or reported by ICES WGBYC, as well as Nammco, in the past 5 years was listed and related to the ASCOBANS limit of maximal anthropogenic removal of 1.7%.

ICES WGBYC (ICES WKEMBYC 2020) evaluated bycatch mortality across métiers for the common dolphin in the Celtic Seas, in the Bay of Biscay and the Iberian Coast, and in the western English Channel. Sustainable anthropogenic removals were defined using the Potential Biological Removal (PBR), concluding in a maximal mortality threshold of 4927 common dolphins per year in the Northeast Atlantic, based on an abundance estimates of 634 286 animals. Based on the limited information available, the at-sea monitoring point estimate of bycatch mortality is just below the PBR, while the point estimate from strandings data exceeded it.

In 2019, ICES WGBYC carried out a bycatch risk assessment for harbour porpoise (*Phocoena phocoena*) and grey seal (*Halichoerus grypus*) in the Celtic Seas and Greater North Sea for 2017. The percentage mortality of the harbour porpoise population in 2017 in nets in the Greater North Sea was between 0.33% and 0.59% (corresponding to 1175–2126 individuals per annum), and in the Celtic Seas in nets and trawls between 0.29% and 0.80% (240–653 individuals per annum). These harbour porpoise bycatch estimates were below the ASCOBANS 1.7% threshold of unacceptable interaction. They are also below the 1% precautionary environmental limit defined by ASCOBANS for bycatch.

However, the harbour porpoise bycatch risk assessment was also carried out for a biologically defined Celtic Seas Assessment Unit (Nammco, 2018) for this species (the Celtic sea and the eastern Bay of Biscay Shelf). Total bycatch in nets in 2017 was estimated to be 536-1,409 animals (>2% of the population abundance), which exceeds ASCOBANS threshold of anthropogenic removal of 1.7%.

In 2017, the percentage mortality of grey seals due to bycatch in the Celtic and Greater North Sea ecoregions combined was estimated to be 1.5 - 2.8% of the best estimate of abundance.

Assessment on bycatch mortality reported by ICES WGBYC, has also been carried out modelling time-series data (from 1990 to 2015) from stranded harbour porpoise, identified as bycaught, along the coasts of the North Sea, English Channel and Bay of Biscay. In the Bay of Biscay, English Channel and Celtic Sea the average annual number of bycaught porpoises was estimated at 530 (330 – 1,030).

At WGBYC 2018, a bycatch risk assessment was carried out for harbour porpoise in the net fisheries in Subarea 7 of the Celtic Sea in 2016, and estimated the bycatch mortality to be 620–1391 harbour porpoises, corresponding to 1,08 to 2,4 % mortality of the population due to bycatch ie above environmental limits defined by ASCOBANS.

The same year an assessment of common dolphin bycatch in the net and midwater trawl fisheries in the Celtic Seas and Bay of Biscay was carried out using data from 2016, resulting in an estimated 1760–5259 common dolphins bycaught that year. The total mortality in both nets and midwater trawls in the Bay of Biscay may exceed ASCOBANS limits in this region, taking into account that the common dolphin in this region is part of one large panmictic population in the NE Atlantic (Murphy et al., 2013).

Estimates of annual mortality from stranding data (2012-2015) were reported in WGBYC (2018). The annual mortality varied from 800–1800 and 1400–4800 for harbour porpoise and common dolphin respectively in the shelf waters of the Bay of Biscay and Celtic Shelf. The approach used is published in Peltier et al. (2016) and has been reviewed by ICES WGBYC (2018) and the International whaling commission (IWC_SC, 2018) noting several uncertainties pertaining to the parameterization of the method. In ICES WGBYC (2016) a bycatch risk assessment for harbor porpoise in the inner Danish waters (3a21, 3b23, 3c22) for 2014 in net fisheries was carried out. The estimated range of potential mortality rates for the harbour porpoise population due to bycatch in 2014 in areas 3a21, 3b23 range between indicating that 165-263 porpoises are being caught it is most likely that < 1% of the harbour porpoise (sub) population in this region is being bycaught.

In 2018, a workshop was carried out by Nammco to assess the current status of harbour porpoise populations in the North Atlantic and adjacent waters, and identified knowledge gaps that need to be filled for sound ecosystem-based management (Nammco 2018). The harbor porpoise population was assessed with regard to bycatch in the following regions in Europe/North Atlantic: Iceland, Faeroe Islands, Norwegian and Russian coast and Belt Sea (and adjacent waters), the Baltic Sea and the Iberian Peninsula. In the Nammco assessment, PBR-informed thresholds were calculated in order to give an idea of what would be an upper limit for safe levels of removal that would still allow the unit to maintain the current population level.

In waters around the Faeroe Islands, the maximal threshold was 36-73 porpoises, dependent on the conservation buffer (recovery rate) chosen. Based on this calculation and on the assumed low levels of direct and bycatch mortality, it was believed that current mortality rates are inside the sustainable level given by PBR.

The PBR-informed threshold for Norwegian waters is estimated around 700, and the current estimates of bycatch exceed this level, meaning that the population is expected to decline under the current regime. The population status in 2016 is 84% of the initial population size in 2006. In the Kattegat and Belt Sea population the PBR-informed threshold was calculated as 330 and 661 using the most recent absolute abundance estimate. Both these threshold values are less than the average annual bycatch estimate for years 2009 - 2017. It was concluded that, because of the declining bycatch estimates, and the relatively large abundance estimates in 2012 and 2016, there is a low to medium level of concern for this assessment unit.

An assessment of the status of the Baltic Proper harbour porpoise (sub) population with regards to fishery bycatch was also carried out. Since there is no bycatch rates to evaluate, the assessment used the abundance estimate, the bycatch numbers estimated from observed bycatch rates in the Belt Sea porpoise population adjusted for fishing effort and the harbour porpoise density in the Baltic Proper. The PBR-informed mortality limit for the Baltic Proper harbour porpoise was estimated to be 0.7 animals per year. Both the estimated bycatch number for 2017 (7 animals) and the minimum bycatch numbers for the years 2000-2012 (average ca 3 animals per year) exceed this level.

ASCOBANS reported in 2019 that bottom-set gillnets and trammel in Bulgarian waters (GSA 29) catch annually 3 016 harbour porpoises and 1895 bottlenose dolphins, with a CPUE of 0.22 and 0.02, respectively. In Romanian waters, an estimated 320 harbour porpoises are bycaught annually in the same fisheries. The harbour porpoise and common dolphin populations are estimated to 29465 and 26462 individuals in this area, respectively, resulting in bycatch take limits (PBR based limit) of 247 individuals for harbour porpoise and 225 individuals for bottlenose dolphin (Birkun *et al.*, 2014).

ICES WGBYC 2015 reported an estimated 18 bottlenose dolphin dying annually from bycatch in the Atlantic coast of Andalusia. With a population estimate of the local population of 397 individuals, the annual removal is reported to be 5%, exceeding the sustainable estimation of 1.7% established by ASCOBANS.

All of the bycatch estimates are biased by the distribution and the "quality" of the monitoring effort, as well as the incomplete fisheries effort data. Therefore, all the described assessments need to be interpreted with caution. Sampling is not representative due to relatively poor observer coverage of the fleets. Monitoring of larger vessels and data collection using fisheries observers (i.e. as part of the DCF) dominate the dataset. Data collected by dedicated monitoring differ from data collected with fisheries observers. In addition, data are not always randomly distributed over the areas, and may for example focus on high risk métiers and areas. Further, field observations have shown that on the monitoring of gillnets a considerable portion of bycaught porpoises may fall out of the net and go undetected. Moreover, assessments based on stranded individuals are generally biased.

However, assessments can serve to flag métiers and areas where further monitoring is necessary, or where mitigation should be considered, and they highlight those species that may be at risk.

Table 19 provides an overview of the assessments conducted and whether bycatch risk exceeded ASCOBANS levels. Nine of the 14 assessments are of harbor porpoise, and only 4 species are assessed in at least one area.

Table 19: Overview of the marine mammal bycatch assessments conducted and whether bycatch risk exceeded ASCOBANS levels. See text for references and details.

Species	Area	Bycatch risk	Bycatch risk exceeding 1.7%?	IUCN status
bottlenose dolphin	Black Sea	?		DD (Europe) LC (Global)
bottlenose dolphin	Atlantic coast of Andalusia	5%	Yes	DD (Europe) LC (Global)
common dolphin	Northeast Atlantic		?	DD (Europe) LC (Global)
common dolphin	Celtic Seas and Bay of		Yes	DD (Europe) LC

	Biscay			(Global)
grey seal	Celtic and Greater North Sea ecoregions	1.5 - 2.8%	No/Yes	LC (Europe) LC (Global)
harbour porpoise	Greater North Sea	?	No	VU (Europe) LC (Global)
harbour porpoise	Celtic Seas assessment unit	2.12%- 5.57%	Yes	VU (Europe) LC (Global)
harbour porpoise	Bay of Biscay and Celtic Shelf	>2%	Yes	VU (Europe) LC (Global)
harbour porpoise	Faroe Islands		No	VU (Europe) LC (Global)
harbour porpoise	Norwegian waters		Yes	VU (Europe) LC (Global)
harbour porpoise	Kattegat belt sea	App. 1%	No	VU (Europe) LC (Global)
harbour porpoise	Baltic Sea	No bycatch assessment carried out	Yes	CR (Global)
harbour porpoise	Black Sea	?		EN (Global)
harbour porpoise	Romanian waters	1.0-1.2%	No	

Reptiles

WGBYC/ICES collated bycatch data for marine turtles from 2016 to 2018 from dedicated (i.e. Reg. 812/2004) and non-dedicated (i.e. DCF) monitoring programmes. The amount of data collected on marine turtle bycatch has improved from 2016–2018. In all years, the loggerhead turtle *Caretta caretta* is the most commonly reported bycaught turtle. Comparison of bycatch rates across years is not recommended given the changes to the data call and inconsistencies in response to the data call. Table 20 presents the degree of bycatch by gear and geographic region for various turtle species for 2016-2018. Extremely few *Dermochelys coricea* and *Chelonia mydas* were recorded. However, these estimates were in general very incomplete, with few fisheries with high percentage observer coverage and/or fisheries subject to studies on bycatch. As a result, comparison of bycatch rates across years should be avoided due to changes to the data call and inconsistencies in response to the data call.

*Table 20: Summary of turtle bycatch records in the WGBYC database 2016 -2018 by gear and ecoregion. No. Spec=number of specimens. Observed effort (Obs Eff) reported as DaS = Days at Sea; bycatch rate = number of specimens/number of days at sea observed. * In 2018, some turtle records were received having been raised (see ToR A Table 2 in WGBYC/ICES 2020).*

	2018			2017			2016		
Species/MetierL3/Ecoregion	**Obs. Effort**	**No Spec.**	**Bycatch Rate***	**Obs. Effort**	**No Spec.**	**Bycatch Rate**	**Obs. Effort**	**No Spec**	**Bycatch Rate**
Total *Caretta caretta*	**5666**	**131**	**0.023**	**599**	**4**	**0.007**	**379**	**12**	**0.032**

Bottom trawls	**4917**	**101**	**0.021**				**25**	**1**	0.040
Adriatic Sea	664	77	0.116						
Aegean-Levantine Sea	198	1	0.005						
Ionian Sea and the Central	1225	8	0.007						
Western Mediterranean Sea	2830	15	0.005				25	1	0.040
Longlines	**363**	**1**	**0.003**				**10**	**1**	**0.100**
Western Mediterranean Sea							10	1	0.100
Pelagic trawls	**386**	**29**	**0.075**	**173**	**3**	**0.017**	**342**	**4**	**0.012**
Adriatic Sea	386	29	0.075						
Western Mediterranean Sea				173	3	0.017	342	4	0.012
Nets				**426**	**1**	**0.002**	**2**	**6**	**3.000**
Western Mediterranean Sea				426	1	0.002	2	6	3.000
Total *Chelonia mydas*							2	1	0.500
Nets							**2**	**1**	**0.500**
Total *Dermochelys coriacea*	**363**	**2**	**0.006**						
Longlines	**363**	**2**	**0.006**						
Total *Cheloniidae*	503	1	0.002						
Total	6532	134	0.021	599	4	0.007	381	13	0.034

GFCM report (FAO, 2019) also presents a synthesis of the information provided by 14 national reports sent by the corresponding Mediterranean countries. Table 21 presents the number of by catch for sea turtles in fisheries in the GFCM competence area for the 2018 according the Recommendation GFCM/35/2011/4. Bycaught on marine turtles were recorded mostly in trawls.

Table 21: Number of by catch incidents for sea turtles based on the Recommendation GFCM/35/2011/4 in the GFCM competence area.

Ecoregion	GSA	MetierL3	Species	Number of incidents
Eastern Mediterranean	22	Bottom trawls	Caretta caretta	1
Eastern Mediterranean	22	Purse seines	Caretta caretta	1
Adriatic	17	Mid-water Trawls	Caretta caretta	10
Adriatic	17	Mid-water Trawls	Caretta caretta	12
Western Mediterranean	6	Bottom trawls	Caretta caretta	1
Central Mediterranean	14	Gillnets	Caretta caretta	1

Seabirds

There is currently no systematic monitoring of seabird bycatch at a regional scale in the Union, which limits the knowledge of overall and species-specific seabird bycatch mortality severely. Besides, the wide distribution range of most of these seabirds implies that bycatch rates need to be estimated across different national fleets to obtain reliable mortality estimates for the entire susceptible populations. However, a few DCF sea sampling (observer) programs and dedicated bycatch-monitoring programs collect data on seabird bycatch routinely. A summary of the implemented programs at the time was published in the JWGBIRD report 2018 (Table 8 of that report).

Regionally, data are often available on seabird population numbers and in some cases enough data exist from fisheries to calculate bycatch rates for individual métiers. For instance, Žydelis et al. (2009) compiled studies and reports reporting seabird bycatch in gillnets at the time in and around the Baltic Sea, summing up to 100 000-200 000 seabirds bycaught annually in the North Sea and the Baltic Sea. The authors also compared the total mortality estimates to the estimated Baltic populations of greater scaup, long-tailed duck and common guillemot. They assessed these populations' vulnerability to bycatch using PBR, and concluded that bycatch mortality was above sustainable levels for all three species. In a later review, Žydelis et al. (2013) assessed seabird bycatch mortality in gillnets globally and estimated that 72 000 drown in gillnets yearly in the Baltic Sea. Nevertheless, without sufficient monitoring of seabird bycatch and fishing effort in most problematic fisheries, the uncertainty of these mortality estimates are likely too wide to target specific fisheries and minimise seabird bycatch.

To our knowledge, there are currently no species-specific time-series to evaluate the variations of seabird bycatch numbers and/or bycatch rates at fisheries level in the EU, although data may exist locally or nationally. With the exception of some interview-based studies (e.g. Bellebaum et al., 2013; Oliveira et al., 2015), most bycatch studies report numbers from observers data on a limited number of vessels (e.g. Soriano-Redondo et al., 2016) or for a limited time period (e.g., Degel et al., 2010). However, long time-series of independent observers data are considered the most reliable to estimate long-term bycatch mortality in commercial fleets (Pott and Wiedenfield, 2017; Le Bot et al., 2018).

The long-term monitoring of the fishing activity of selected vessels by independent observers and/or using electronic monitoring (EM) with videos shows that it is possible to obtain accurate mean bycatch estimates at a species-level. These estimates can then be extrapolated to fleet-level, provided fishing effort data are available at the same resolution. Currently, only Denmark and Sweden have an EM program dedicated to collecting bycatch data in their national coastal gillnet fisheries (which are considered the most problematic with regards to bycatch of seabirds in the region). Studies such as Glemarec et al. (2020) showed that, in the Danish gillnet fishery in Eastern Denmark, three species constitute 90% of all bycatch (in number of individuals captured) (Table 22). This approach can also inform on the number of casualties per species and on the temporal variations of bycatch. In addition, in this study, the long-term monitoring showed that rare bycatch events, where several dozens of individuals of the same species can be caught at once, are responsible for 40% of the total bycatch of seabirds in the region.

Table 22: Seasonal variations of the number of birds taken as bycatch in gillnet, grouped by family and species; the corresponding bycatch per unit effort (expressed as the number of birds per kilometre.hour) is indicated in the parentheses. The identification is given at the lowest possible level (species, genus, family). Data were recorded on three electronically monitored Danish commercial gillnetters in the Øresund for the period 2010-2018 (spring = March, April and May; summer = June, July and August; fall = September, October and November; winter = December, January and February). From Glemarec et al. (2020)

Family	**Species**	***% total bycatch***	**Spring**	**Summer**	**Fall**	**Winter**	**YEAR**

Anatidae	Common eider *Somateria mollissima*	***58.4***	n = 106 (0.000606)	n = 14 (0.000289)	n = 236 (0.054200)	n = 53 (0.007150)	**n = 409 (0.001758)**
	Scoter *Melanitta spp.*	***3.1***	n = 2 (0.000007)	-	n = 18 (0.000383)	n = 2 (0.000006)	**n = 22 (0.000099)**
	Not identified	***0.4***	n = 2 (0.000008)	-	n = 1 (0.000026)	-	**n = 3 (0.000009)**
Phalacrocoracidae	Great cormorant *Phalacrocorax carbo*	***19.6***	n = 2 (0.000008)	n = 15 (0.000417)	n = 84 (0.002272)	n = 36 (0.009180)	**n = 137 (0.009040)**
Alcidae	Common guillemot *Uria aalge*	***12.4***	n = 1 (0.000003)	-	n = 39 (0.001335)	n = 47 (0.001954)	**n = 87 (0.000823)**
	Razorbill *Alca torda*	***2.3***	-	n = 1 (0.000024)	n = 8 (0.000136)	n = 7 (0.000096)	**n = 16 (0.000064)**
	Not identified	***1.0***	n = 4 (0.000013)	-	n = 3 (0.000077)	-	**n = 7 (0.000023)**
Laridae	Gull *Larus spp.*	***0.4***	n = 1 (0.000002)	n = 1 (0.000014)	n = 1 (0.000011)	-	**n = 3 (0.000007)**
Gavidae	Loon *Gavia spp.*	***0.6***	n = 1 (0.000005)	-	n = 3 (0.000073)	-	**n = 4 (0.000019)**
Podicipedidae	Great crested grebe *Podiceps cristatus*	***0.4***	-	-	-	n = 3 (0.000047)	**n = 3 (0.000012)**
	Red-necked grebe *Podiceps grisegena*	***0.1***	-	n = 1 (0.000031)	-	-	**n = 1 (0.000008)**
Unidentified bird		***1.1***	n = 1 (0.000002)	n = 1 (0.000007)	n = 2 (0.000033)	n = 4 (0.000093)	**n = 8 (0.000034)**
All birds		**100%**	**n = 120 (0.000653)**	**n = 33 (0.000782)**	**n = 395 (0.009430)**	**n = 152 (0.003142)**	**n = 700 (0.003300)**

Table 23: Overview of the seabird bycatch assessments conducted and whether bycatch risk exceeded reference levels. See text for references and details.

Species	Area	Bycatch risk exceeding reference level?	IUCN status
Common guillemot	Baltic Sea	Yes	NT
Long-tailed duck	Baltic Sea	Yes	VU

Greater scaup	Baltic Sea	Yes	VU

Fish

In general, fish (including elasmobranchs) are monitored in scientific surveys in all areas. However, many of the species are too rare to occur frequently enough to allow an evaluation of development in stock status: only half the species observed in the ICES survey data base are observed more than half of the years[6], and in addition, a number of species have never been observed in the surveys (e.g. *Squatina squatina*).

The Mediterranean Sea has been identified as one of the 3 hotspots where the biodiversity of the 49 sharks and 36 rays, recorded in this area, is seriously threatened, with bycatch being the most significant threat for the their conservation (Dulvy et al., 2014). In this area, more than half the sharks and rays (53% of all) are threatened with extinction, extirpations, and steep population declines (Dulvy et al., 2016) with 13 species being still considered data-deficient (Walls & Dulvy, 2020). None of the red listed fish species have assessments of populations development and bycatch. In the Mediterranean, WGBYC/ICES analysed bycatch data for fish species for the years 2017 and 2018 from dedicated (i.e. Reg. 812/2004) and non-dedicated (i.e. DCF) monitoring programmes (Table in Annex Table A1). More than half (51.7%) of the total number of by catch incidents were derived from three elasmobranch species, *Etmopterus spinax*, *Mustelus mustelus* and *Squalus acanthias*. Almost a third of these by catch incidents (28.3%) were caught in Adriatic Sea (GSA 17) and to a lesser extent in Aegean Sea (GSA 22) and Western Mediterranean (GSA 2).

Analysis of the relationship between the presence of species specific landing restrictions and the recent development of 31 sensitive fish species in the Northeast Atlantic concluded that there was no relationship between the two[2].

The study used life-history parameters and knowledge of fish shape and habitat to estimate the sensitivity of 270 species in the Northeast Atlantic to demersal trawling and compare sensitivity to the most recent IUCN categorization. Species classified as threatened were on average significantly more sensitive to trawling than other species. Indicators of abundance of 31 highly sensitive species were derived from ICES DATRAS survey data and compared changes in abundance to sensitivity, management measures, and value of landings.

The abundance of 23 of the 31 sensitive species increased after year 2000 with 14 of the species showing increases significant at the 5% level (table 24). The increases were not due to specific management measures, as less than half of the species were covered by catch limits. Furthermore, sensitivity or value of landings was not related to trends in abundance. Three species (*Anarhichas lupus*, *Brosme brosme* and *Amblyraja radiata*) declined significantly. These species are all at their southern distributional limit in the North Sea.

The change in abundance has been added to the table of sensitive species in annex 1. Among the species listed by IUCN as Critically Endangered, Endangered or Vulnerable, four taxa increased significantly after 2000 (*Dipturus* spp., *Leucoraja circularis*, *Mustelus* spp. and *Squalus acanthias*) whereas four showed no significant change (*Dasyatis pastinaca*, *Galeorhinus galeus*, *Leucoraja fullonica* and *Hippoglossus hippoglossus*). Among the species assessed as Least Concern, *Brosme brosme* and *Amblyraja radiata* and *Torpedo marmorata* all decreased significantly from 1980 to 2018.

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[6] Rindorf, A., Gislason, H., Burns, F., Ellis, J. R., & Reid, D. (2020). Are fish sensitive to trawling recovering in the Northeast Atlantic?. Journal of Applied Ecology.

Reliable catch data are generally available for the valuable ray-finned and elasmobranch fishes (*Anarhichas lupus*, *Brosme brosme, Hippoglossus hippoglossus, Galeorhinus galeus, Dicentrarchus labrax*, *Lepidorhombus whiffiagonis*, *Scophthalmus rhombus*, *Lophius budegassa and L. piscatorius*, *Etmopterus princeps*, *Macrourus berglax*, *Molva dypterygia, Molva macropthalma, Molva molva, Scyliorhinus canicula, Scyliorhinus stellaris, Sebastes spp. and Squalus acanthias*) as these species are generally retained when caught and hence landings data are at least indicative of realised catches. The remaining species are categorized as low value species and are often discarded, making landing data a poor proxy for actual catches. Further, elasmobranch species are in sometimes poorly identified to species, making the data less reliable than for ray-finned fishes.

A few of the sensitive species have recent ICES stock assessments and associated evaluations of fishing mortality, allowing evaluations of the recent development in fishing pressure for at least part of their natural range (Table 26). This encompasses the species in table 25 below. Seven of the 18 stocks are either fished above the agreed F reference point or have biomasses below the agreed BMSY trigger. The remaining stocks have both F below target and biomass above target. In addition to these assessments, there are evaluations based on catches only and evaluations of *Salmo salar*.

Table 24: Sensitive species for which status or fishing pressure is evaluated against agreed reference points by ICES.

Species	Area	Status	link	IUCN rating
Anguilla anguilla	Natural range	B<BMSY trigger proxy	https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2019/2019/ele.2737.nea.pdf	CR
Brosme brosme	Subareas 4 and 7–9, and divisions 3.a, 5.b, 6.a, and 12.b (Northeast Atlantic)	F<FMSY proxy, B>BMSY trigger proxy	https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2019/2019/usk.27.3a45b6a7-912b.pdf	LC
Dicentrarchus labrax	divisions 4.b–c, 7.a, and 7.d–h	F<FMSY proxy, B<BMSY trigger proxy	https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2020/2020/bss.27.4bc7ad-h.pdf	LC
Dicentrarchus labrax	divisions 8.a–b	F<FMSY proxy, B>BMSY trigger proxy	https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2020/2020/bss.27.8ab.pdf	LC

Lepidorhombus whiffiagonis	divisions 7.b–k, 8.a–b, and 8.d	F>FMSY proxy, B>BMSY trigger proxy	https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2020/2020/meg.27.7b-k8abd.pdf	LC
Lepidorhombus whiffiagonis	divisions 4.a and 6.a	F<FMSY proxy, B>BMSY trigger proxy	https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2020/2020/lez.27.4a6a.pdf	LC
Lepidorhombus whiffiagonis	divisions 8.c and 9.a	F>FMSY proxy, B>BMSY trigger proxy	https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2020/2020/meg.27.8c9a.pdf	LC
Lophius budegassa	Subarea 7 and divisions 8.a–b and 8.d	F<FMSY proxy	https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2020/2020/ank.27.78abd.pdf	LC
Lophius budegassa	divisions 8.c and 9.a	F<FMSY proxy, B>BMSY trigger proxy	https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2020/2020/ank.27.8c9a.pdf	LC
Lophius piscatorius	divisions 8.c and 9.a	F<FMSY proxy, B>BMSY trigger proxy	https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2020/2020/mon.27.8c9a.pdf	LC
Lophius piscatorius	Subarea 7 and in divisions 8.a–b and 8.d	F<FMSY proxy, B>BMSY trigger proxy	https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2020/2020/mon.27.78abd.pdf	LC
Molva dypterygia	subareas 1, 2, 8, 9, and 12, and in divisions 3.a and 4.a	B<BMSY trigger proxy	https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2019/2019/bli.27.nea.pdf	VU
Molva	subareas 6–7 and	F<FMSY proxy,	https://www.ices.dk/sites/pub/Publicati	VU

dypterygia	Division 5.b	B>BMSY trigger proxy	on%20Reports/Advice/2020/2020/bli-5b67.pdf	
Molva molva	subareas 6–9, 12, and 14, and in divisions 3.a and 4.a	F<FMSY proxy	https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2019/2019/lin.27.3a4a6-91214.pdf	LC
Scophthalmus maximus	Division 3.a	F<FMSY proxy, B>BMSY trigger proxy	https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2020/2020/tur.27.3a.pdf	VU
Scophthalmus rhombus	Subarea 4 and divisions 3.a and 7.d–e	F<FMSY proxy, B>BMSY trigger proxy	https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2020/2020/bll.27.3a47de.pdf	VU
Squalus acanthias	subareas 1–10, 12, and 14	F<FMSY proxy, B<BMSY trigger proxy	https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2020/2020/dgs.27.nea.pdf	EN

In summary, the majority of the sensitive fish stocks are not protected by stock specific technical measures. However, concurrent with the decrease in fishing effort over the past 20 years, there has been an increase in the stock of more than half of the sensitive species for which data are available. Species without sufficient data, species red listed and not increasing (*Dasyatis pastinaca, Galeorhinus galeus, Leucoraja fullonica* and *Hippoglossus hippoglossus*) and species showing prolonged decline (*Brosme brosme, Amblyraja radiata* and *Torpedo marmorata*) are expected to continue to be at risk to fishing under the current regulation.

Species at risk for which insufficient information exist on bycatch rates

Mammals

Marine mammals that can occur in the ecoregions Barents Sea, Norwegian Sea, Faroes, Iceland Sea, Oceanic north-east Atlantic, Azores, Bay of Biscay and the Iberian Coast, Celtic Sea, Greater North Sea, and Baltic Sea is listed in Annex 1. Of the 47 marine mammal species almost all are susceptible to interactions with fisheries though some of them might not have been reported as bycatch (Annex 1 of this report). 10 species are listed as Least Concern on the IUCN Red List, 2 are Near Threatened (*Balaenoptera physalus, Balaenoptera bonaerensis*), 2 are Vulnerable (*Phocoena phocoena, Ursus* *maritimus*), 4 are Endangered (*Physeter microcephalus, Balaenoptera borealis, Balaenoptera musculus, Sousa plumbea*) and 2 is Critically Endangered *(Eubalaena glacialis, Monachus monachus*). 14 species are Data deficient and 13 species are listed as Not available. Only a few assessments on data deficient, vulnerable or least concern species has been conducted (*Delphinus delphis, Phocoena phocoena, Halichoerus grypus).* Of the eight species listed as Endangered, Criticaly endangered, Near threatened, none has a recent assessment of both population estimates and bycatch mortality estimates at population level.

Reptiles

The loggerhead sea turtle *Caretta caretta* and the leatherback turtle *Dermochelys coriacea* have been reported by numerous sightings in the Bay of Biscay and the North East Atlantic which are considered to be foraging areas for these species (Zaldua-Mendizabal et al., 2013). The two species are also found in the Iberian Coast (ICES Ecosystem Overviews 2019), and strandings have been reported in the Azores, both for *Caretta caretta* and *Dermochalys coriacea*, Gwynedd, and Nova Scotia, for *Dermochalys coriacea*.(Nelms et al., 2015)

The Mediterranean Sea hosts local populations of two sea turtle species, the loggerhead turtle and the green turtle *Chelonia mydas*. Among them, the loggerhead turtle is the most frequently encountered and the most widely distributed species in the Mediterranean (Casale et al., 2018). Both species have resident breeding populations in the Eastern basin with juvenile loggerheads from Atlantic breeding populations regularly occur in the Western basin. Leatherback turtles *Dermochelys coriacea* also enter the Mediterranean from the Atlantic to forage, though none breed, and encounters are scarce. Only a few large juvenile or adult leatherback turtles *Dermochelys coriacea* enter the Mediterranean from the Atlantic, without breeding in the basin (Casale et al. 2003). The Mediterranean Sea exhibits the highest bycatch rates of loggerhead turtle (Casale, 2008; Wallace et al., 2008; Casale et al., 2018). The IUCN Red List includes both *Caretta caretta* and *Dermochelys coriacea* as vulnerable and *Chelonia mydas* as endangered. The Mediterranean sub-population of *Caretta caretta* (Wallace et al. 2010) is classified as Least Concern, with the condition that conservation efforts are maintained.

For the rest of marine turtle species encountered in the Mediterranean (i.e., *Eretmochelys imbricate*, *Lepidochelys kempii*, *Lepidochelys olivacea* and *Trionyx triunguis*) it is assumed that it is highly unlikely to be observed by onboard observers (Otero et al., 2019) and especially the first three of them enter the Mediterranean basin very scarcely. A Mediterranean subpopulation of a freshwater species, the African softshell turtle *Trionyx triunguis*, may be encountered in coastal and estuarine fisheries of Eastern Mediterranean. Israel and Turkey hosts a significant population of *T. triunguis* (Tagkavak and Farkas, 1998), whereas isolated sightings have been also reported in Greece, Lebanon and Syria (Corsini-Foka and Masseti, 2008). In an effort to conserve *T. triunguis*, it has been included in Appendix II of the Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention), and in Appendix III of The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). The Mediterranean population used to be listed as "Critically Endangered" in the IUCN's Red List (1996 and 2000) but has not been assessed by the current Red List.

The current monitoring does not provide enough information on sea turtle populations and more detailed information on sea turtle biology, such as survival rates and breeding patterns, is needed to predict and understand changes in populations in order to develop estimates of bycatch levels posing a threat and hence successful management and conservation plans.

Seabirds

Of the 29 seabird species listed in Annex I of the Birds Directive and susceptible to bycatch in fishing gears (Annex 1 of this report), 19 species are listed as Least Concern on the IUCN Red List, 3 are Near Threatened (*Larus minutus*, *Podiceps auritus*, *Pterodroma feae*), 3 are Vulnerable (*Gavia immer*, *Hydrobates leucorhous*, *Polysticta stelleri*), 2 are Endangered (*Pelagodroma marina*, *Pterodroma madeira*) and 1 is Critically Endangered *(Puffinus mauretanicus*). One species is not listed (*Puffinus assimilis baroli*). Among the 6 species that are listed on the red list, none has a recent assessment of both population estimates and bycatch mortality estimates at population level.

Fish

Red listed fish species with insufficient data available to the group to evaluate stock status and bycatch effects relative to agreed reference levels include the ray-finned fish *Acipenser naccarii, Acipenser stellatus, Acipenser sturio, Anarhichas denticulatus, Aphanius iberus, Bodianus scrofa, Coregonus lavaretus, Coregonus maraena, Dentex dentex, Epinephelus marginatus, Hippoglossus hippoglossus, Hoplostethus atlanticus, Labrus viridis, Mycteroperca fusca, Orcynopsis unicolor, Pomatoschistus tortonesei, Sebastes mentella, Sebastes norvegicus and Umbrina cirrosa*, the rays *Aetomylaeus bovinus, Bathytoshia centroura, Dasyatis pastinaca, Dasyatis tortonesei, Deania calcea, Glaucostegus cemiculus, Gymnura altavela, Leucoraja melitensis, Manta alfredi, Mobula eregoodootenkee, Mobula hypostoma, Mobula japonica, Mobula kuhlii, Mobula mobular, Mobula mobular, Mobula munkiana, Mobula rochebrunei, Mobula tarapacana, Mobula thurstoni, Myliobatis Aquila, Pristis pectinate, Pristis pristis, Pristis zijsron, Raja radula, Rhincodon typus, Rhinobatos cemiculus, Rhinobatos rhinobatos* and *Rostroraja alba*, and the sharks *Alopias pelagicus, Alopias superciliosus, Alopias vulpinus, Anoxypristis cuspidate, Carcharhinus longimanus, Carcharhinus plumbeus, Carcharias taurus, Carcharodon carcharias, Centrophorus cf granulosus, Centrophorus squamosus, Centroscymnus coelolepis, Cetorhinus maximus, Dalatias licha, Echinorhinus brucus, Eusphyra blochii, Isurus oxyrinchus, Lamna nasus, Mustelus punctulatus, Odontaspis ferox, Oxynotus centrina, Prionace glauca, Pristis clavata, Pristis pectinate, Sphyrna zygaena, Squatina aculeate, Squatina oculata* and *Squatina squatina*. Together, this amounts to 5 species of diadromous fish, 13 species of marine fish, 28 species of rays and 27 species of sharks.

Evaluations for the stock status development and/or fishing mortality rates in the Northeast Atlantic by either ICES or peer reviewed publications exists for the red listed species *Anguilla Anguilla*, *Galeorhinus galeus, Mustelus asterias, Mustelus mustelus* and *Squalus acanthias*. Among these, *Anguilla anguilla* is depeleted (ICES 2020), *Galeorhinus galeus* is not increasing, *Mustellus spp*. are increasing significantly and *Squalus acanthias* is below BMSY trigger but increasing with F<FMSY.

Achievement of objectives of Article 3 and 4

Among the red-listed fish species, the status development of 5 species of diadromous fish, 13 species of marine fish, 28 species of rays and 27 species of sharks cannot be evaluated due to lack of data. Among the 5 red-listed species with enough data to evaluate population trends, *Mustellus spp*. and *Squalus acanthias* are increasing while *Anguilla Anguilla* and *Galeorhinus galeus* are not. Among the 31 sensitive species in the Northeast Atlantic where abundance changes could be estimated, 14 were increasing significantly in the most recent period. The increase occurred concurrently with a general decrease in fishing effort.

There is very limited data to reflect historic development in population size and/or bycatch of mammals, seabirds and reptiles. As a result, the evaluation of whether objectives are achieved cannot be directly evaluated. However, the group noted that the effort in static gear in the Baltic Sea has decreased substantially in the later years and hence pressure on seabirds and mammals in this area is expected to have decreased. In the Northeast Atlantic, fishing effort (primarily trawl) has decreased over the past 20 years with an expected associated decrease in the pressure on sensitive species. In the Mediterranean, no decrease in fishing pressure has occurred and as a result, no decrease in bycatch mortality of sensitive species is expected to have occurred.

Suggestions for further work and monitoring of bycatch rates

A first requirement to assess species bycatch is that all species observed are allocated correctly to species. For seabirds and elasmobranchs, this may require further education of observers or alternative approaches such as identification from photos taken. Further, reference points for bycatch risks leading to a risk to the population should be specific to the life history characteristics of the population in question under the prevailing conditions, including other pressures.

To be able to relate bycatch in numbers to bycatch mortality, species-specific population abundances must be assessed. These should be conducted on a regular basis to allow detection of population trends over time. Information on population distribution is also important and can be used, together with spatial data on fishing effort, to develop bycatch risk maps, showing areas of high risk of bycatch. In European waters, a large scale survey evaluating the population abundance and distribution of small cetaceans is carried out every 10 year (Scans I, Scans II). It is important to continue carrying out such large-scale surveys. It is also recommended to set up regional projects monitoring species-specific abundance over a short time period.

Population abundance and demographics of seabirds in EU waters (corresponding respectively to criteria D1C2 and D1C3 of the MSFD) are assessed either nationally, regionally, or both, depending on the Member States. Population abundance assessments generally use a combination of shore-based, aerial and boat surveys depending on the Member States (ICES 2016). In addition, at-sea monitoring programs are well underway in some regions (e.g., in the Baltic Sea) to reduce the uncertainty of these estimates. JWGBIRD (ICES 2020) compiled the details of the MSFD seabird assessments for each Member State in the OSPAR and HELCOM regions (MS in the Mediterranean Sea and the Black Sea were not included). National assessments for the abundance of migratory birds (including seabirds) were conducted in 3 out of 18 MS, while 14 out of 18 conducted demographic assessments (Annex 3 in ICES (2020)).

A series of shortcomings have been identified in the implementation of Regulation (EU) 812/2004 (ICES WGBYC 2020, STECF EWG 19-07, ICES WKREV812 2010, FAO report on the sustainability of Mediterranean and Black Sea fisheries 2019b). In the Mediterranean Sea, the highest impact on sensitive species (fish, cetaceans, marine turtles and marine birds) by catch were mostly derived from fishing gears characterized by demersal nature, namely bottom trawls, bottom longlines and set nets. These gear types are also characterised by a variety of métiers of the same gear that can have a different impact on species by catch, suggesting that, in the Mediterranean, a métier-based approach is needed to provide realistic estimates of sensitive species bycatch (Cambie et al. 2020). The variability of fishing methods and métiers implies that the most effective management strategies should be identified at relatively small geographical scales.

Many species of fish are caught in trawl surveys and indices of their abundance can be derived from this source, preferably combined to the population level.

The paucity of information on mammal, seabird, reptile and sensitive fish bycatch in EU fisheries prevents to calculate reliable mortality estimates for a large number of susceptible species. In addition, the fishing effort data reported nationally and at Union-level is not always adequate to scale up observed bycatch numbers. For example, gillnet fishing effort is often reported only as Days at Sea, regardless of vessel overall length, whereas the length of fishing nets and the soak duration are known to influence bycatch rates greatly for all vulnerable taxa (Northridge et al., 2017). Indeed, nominal and effective fishing effort may be very different in gillnet fisheries if the fleet is constituted of numerous vessels of different length classes.

Currently, ICES provides advice on the likely impacts of fisheries on marine mammals, seabirds and marine turtles, based on reported bycatch data received through the ICES data call. Bycatch incidence is monitored as an indication of species/taxa interacting with fisheries, enabling bycatch rates to be estimated and used as an indicator of potential impact from fishing activities. However, for many years, ICES has concluded that the present monitoring and data reported for many areas and métiers is, in most cases, insufficient and inconsistent for ICES to provide reliable bycatch estimates and assessments, a fact that is clearly reflected in the larger number of sensitive and redlisted species for which no data on bycatch are available. Also, ICES WGBYC 2020 provided an overview of the state of monitoring in relation to risks for bycatch by subdivision. There was a clear relationship between risk of bycatch and monitoring effort, where the majority of métiers with more than 5% observer coverage were mobile gears, generally presenting a lower risk to seabirds, mammals and reptiles, whereas gillnet fisheries have high risk of bycatch, but relatively low levels of observer coverage. Therefore, ICES WGBYC 2020 concluded that considering that Member States are required to monitor protected species bycatch, the Regional Coordination Groups may consider refocusing relative observer effort from active to more problematic passive fisheries, mainly gillnets.

6. TOR 6 - Impacts of fisheries on habitats

Ideally, Joint Recommendations proposing closed areas aiming at protecting sensitive habitats should be submitted with supporting documentation (Art 21 of the TMR) that may:

(a) Develop lists of sensitive species and habitats most at risk from fishing activities within the relevant region based on the best available scientific advice;

(b) specify the use of additional or alternative measures to those referred to in Annex XIII to minimize the incidental catches of the species referred to in Article 11;

(c) provide information on the effectiveness of existing mitigation measures and monitoring arrangements;

(d) specify measures to minimize the impacts of fishing gear on sensitive habitats;

(e) specify restrictions on the operation of specific gears or introduce a total prohibition on the use of a specific fishing gear within an area where such gear represents a threat to the conservation status of a species in that area as referred to in Articles 10 and 11 or in other sensitive habitats.

Habitats most at risk from fishing: VMEs

Highly diverse habitats formed by coral communities are very sensitive to degradation, and long-term protection measures implemented after impact will only allow a full recovery of impacted coral communities over a very long-time scale (Bennecke and Metaxas 2017). Deep-sea waters potentially host Vulnerable Marine Ecosystems (VMEs) and as a consequence, an EU Regulation was introduced in 2016 which banned trawling in deep-sea waters. It, stipulated that future fishing should not extend outside the historical footprint over the reference period of 2009-2011 (to avoid creating anteriority effects, whereby fishers fish in a new area in order to claim rights to continue to fish in the future).

VMEs are defined by the FAO criteria from 2009 base don (1) uniqueness or rarity; (2) functional significance of the habitat; (3) fragility; (4) life-history traits of component species that make recovery difficult; and (5) structural complexity. Because no threshold values were provided along with the criteria, ICES WGDEC has further qualified these criteria to define what constitutes VMEs.

VMEs occurrences (ICES VME database) obtained by WGDEC, overlaid with spatial fishing footprints obtained from ICES WGSFD, are displayed on an ICES GIS platform requested by DG MARE (screenshot below, the platform is not public), and was further presented to stakeholders during WKREG. The platform was developed in response to a DG MARE special request to ICES for advice on VMEs (ICES, 2018 https://doi.org/10.17895/ices.pub.4429). To use the map to help policymakers in selecting areas for further effort, , ICES WKREG recognized that the map needs to include further information on the research survey coverage. VMEs locations are currently based on collecting fisheries-independent data. Identifying areas with the absence of VMEs from the areas with no sample is seen as essential as only a small proportion of the deep areas are sampled due to the large areas of the ocean.

To complement the visual research survey data (using remotely operated vehicle, ROV, or towed/drop camera seabed imagery), models have been developed to predict possible occurrences of VMEs and fill the gaps in their distribution. These models can identify potential areas based on Species Distribution Modelling and Habitat Suitability Modelling. An index of occurrences is complemented with commercial data on incidental catches of vulnerable species. The operational method based on a multi-criteria classification and is deployed within ICES WGDEC, as a "VME weighting system" as described in Morato et al. (2018):

Step 1: Vulnerability Index (FAO criteria, uniqueness, fragility, life-history traits, etc.)

Step 2: Abundance 30kg coral or 200 kg of sponge in trawl hauls

Step 3: Weighting: 0.9*step1 vs 0.1*step2 to return an integrative index

Step 4: Level of confidence in the data per grid cell (depending on the type of surveys, nb of surveys in each grid cell, the period of the survey, time of the last survey)

VMEs are classified in categories (ICES WGDEC 2020) in the ICES VME database as

- 'VME habitats' obtained from visual evidence, '
- VME indicators for which there is a degree a certainty, (e.g. from trawl or longline bycatch records), and
- 'VME elements' that refer to topographic features known to host VMEs.

VMEs addressed by the EU deep-sea access regulation are all deeper than 400m. However, there may also be VMEs between 0-400m. There is evidence that fishing on VMEs impact the most vulnerable fish species first. The least vulnerable species are left and then find room to grow. The habitat will subsequently no longer meet the criteria defining a VMEs while still having the potential to be one.

ICES advised DG MARE in 2018 on the deep-sea bottom fisheries footprint, for depths of 200 m and greater, based on VMS and logbook data for the years 2009–2011 (Figure 61). Information from some fleets is missing as data was not supplied to ICES. ICES also advised on where this footprint is bisected by the 800 m depth contour, below which bottom trawling is prohibited under the EU deep-sea access Regulation (EU) 2016/2336.

ICES advised on a methodology to identify areas with vulnerable marine ecosystems (VMEs) and those likely to contain VMEs that may be used as a basis for implementing the habitat protection aspects of Regulation (EU) 2016/2336. Based on scientific advice need to decide on how to prioritize which areas to close for habitat protection. In the advice to DGMARE, ICES provided potential options for a prioritization scheme for an example, an area off NW Scotland and the Rockall Bank.

New presence records totalling 4609 have been submitted to the ICES VME database since June 2019, which increased the total number of presence records in the database to 61 200 (ICES WGDEC 2020, some VMEs are represented by more than one record). Each year, a data call is sent out to EU Member States requesting any new data on VMEs be submitted to allow inclusion in the VME Database. WGDEC 2020 lists the areas with new, historical or resubmitted VME data to the ICES VME data call:

- Areas considered within the NEAFC Regulatory Area: Rockall Bank, Reykjanes Ridge (Figure 62)
- Areas considered within the NAFO Regulatory Area: Flemish Cap
- Areas considered within the EEZs of various countries: Rockall Bank and George Bligh Bank, Anton Dohrn Seamount, Faroe Shetland Channel, Darwin Mounds, Hebridean Slope (Scotland), Scottish and Irish Continental Slopes, Porcupine Bank and Seabight, Icelandic Continental Slope and Reykjanes Ridge, Norwegian Trench and Danish and Swedish Continental Slopes

For each area, WGDEC 2020 provided maps of the new VME indicator and/or habitat records, the outputs of the VME likelihood index based on the VME weighting algorithm, and the associated VME index confidence layer.

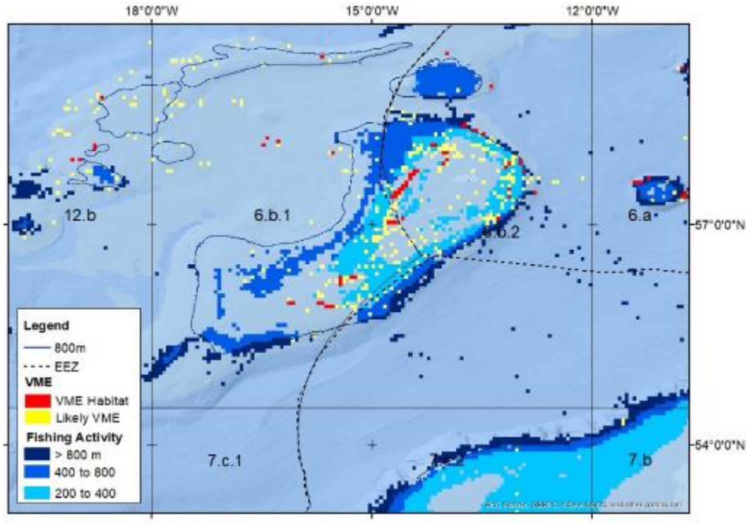

Figure 61: Known VME habitats and an example of expressing "likely VME" using c-squares with high and medium VME index, with any level of confidence, and the bottom fisheries footprint (2009–2011), for Division 6. b (extracted from ICES Advice 2018)

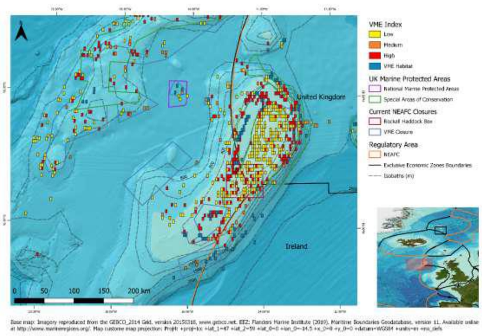

Figure 62: Output of the VME weighting algorithm for the Rockall Bank area showing the VME Index; the likelihood of encountering a VME within each grid cell (ranging from low to high); and presence of actual VME. (extracted from WGDEC 2020)

Fishing impacts VMEs through bycatch of fragile seabed invertebrates (seapen, cold corals, etc.) and indirectly by degrading the physical structure of marine habitats (boulder, smothering, sediment resuspension etc.). Through these, fishing on vulnerable habitats impacts the suitability of resident ecosystems. There is evidence of fishing both impacting fragile benthic invertebrate communities with bycatch and affecting the bio geophysical and chemical conditions of sensitive habitats. The impact depends on the fishing gear used, the type of habitat and the fishing intensity:

- Bottom trawling suspends surface sediment that can then be transported away and influence biogeochemical processes. Bottom fishing impacts the habitat suitability for resident ecosystems (Oberle et al. 2016) by altering the vertical porosity and geochemical content of the sediments by creating possible smoothing of the seabed (Daly et al. 2018). Bottom trawling and dredging reduce habitat complexity by removing or damaging the physical structure of the seafloor and by causing changes in species composition.

- Longlining affects cold-corals by fracturing and incidentally transporting them away while some commercially important fish species are associated with seamounts making them very attractive to fisheries. Longline in outermost regions shows bycatch of cold-water corals, (e.g. coral gardens species) often accidentally captured as bycatch during longline fishing operations (Braga-Henriques et al. 2013).
- Pelagic trawls for widely distributed fish may sometimes be fished close to the seabed and are suspected to impact seamounts area the same way as bottom trawling (ICES 2019 in Western Waters).

Fished areas where there is information available to identify recovery

Habitats may exhibit shorter recovery times than VMEs and hence greater rebuilding potential. The working group on Fisheries Benthic Impact and Trade-offs (WGFBIT) developed methods and carried out assessments to evaluate the benthic impact from fisheries at the regional scale while considering fisheries and seabed impact trade-offs. The group evaluated ways of modelling the sensitivity of seabed habitats to disturbances such as bottom fishing and produced maps and indicators for measuring the effects of such human activities on the seabed. This information is used to estimate the impact of fishing pressure, set reference values for avoiding habitat degradation, and inform managers about the interlinkages, and, therefore, tradeoffs, between benthic impacts and revenues generated from fishing. This information is required to explore management options and the likely consequences of prohibiting or restricting fishing.

WGFBIT focused on both developing new assessment methods, as well as using existing ones The methods incorporated aspects of both the structure and function of benthic communities. Using these methods, the aim is to derive safe biological limits to fishing impact (covering both spatial and temporal aspects), (e.g. in relation to the amount of habitat fragmentation an area can withstand before its ability to recover will be affected). Standard structured regional outputs from the WGFBIT assessment workflow, in terms of pressure, sensitivity and impact estimates, were produced and presented for each region. This is a significant step towards the WGFBIT term of reference 'to produce a framework for MSFD D6/D1 assessment related to bottom abrasion of fishing activity at the regional scale'. WGFBIT collaborated with the spatial fisheries data (WGSFD), benthic ecology (BEWG) and ecosystem effects of fishing (WGECO) working groups.

Based on this work ICES received a special request in January 2020 from DG ENV to "advise on a set of management options to reduce the impact of mobile bottom contacting fishing gears on seafloor habitats, and for each option provide a trade-off analysis between fisheries and the seafloor". The request builds upon the advice provided by ICES in 2017 (ICES advice eu.2017.13), which presented an analysis of the environmental impact to the seabed from bottom-contacting fishing gear. This analysis indicated that each type of fishing (metier) has a fishing pattern which is reasonably constant, at the scale of c-squares. ICES was requested to provide analyses of the present spatial and temporal variation in fishing intensity, catch and landings in a way, appropriate to assess the footprint of mobile bottom contacting fishing gears in a six-year management cycle. This work is ongoing.

ICES WGFBIT 2019 initiated an assessment of the impact of bottom-contacting gears within 5 ICES ecoregions applying the WGFBIT 2018 methodology. From the extent of surface abrasion created by fishing in each ecoregion (on a 0.05° × 0.05° grid) overlaid to broad-scale (2019 Level 3 EUNIS) habitats, the assessment deduced a geographical impact layer (e.g., Figure 63 for the Greater North Sea ecoregion) and provided time series for the % area impact per habitat type at a different level of impacts (Figure 64 for the Greater North Sea ecoregion).

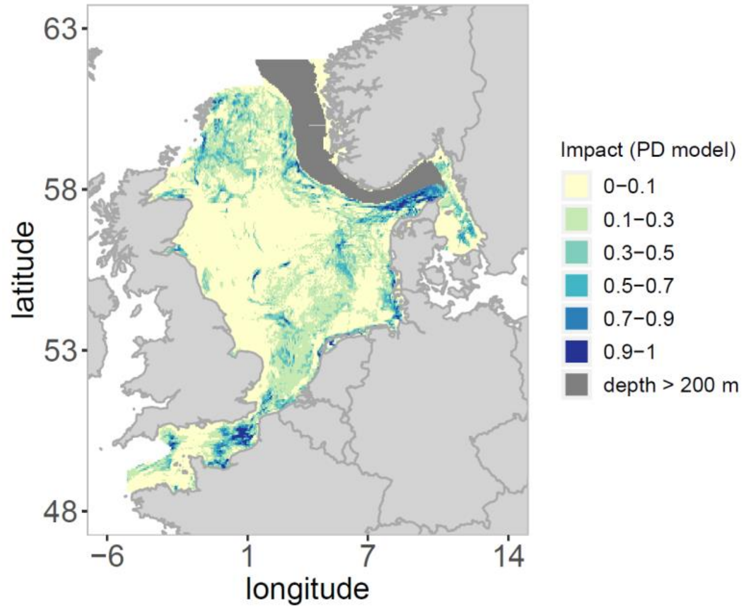

Figure 63: Impact of abrasion on the benthic biomass. The impact is calculated following the PD method. The highest impact is found in areas with high sensitivity and high abrasion. Low impact means low abrasion, low sensitivity or both fisheries (extracted from ICES WGFBIT 2019).

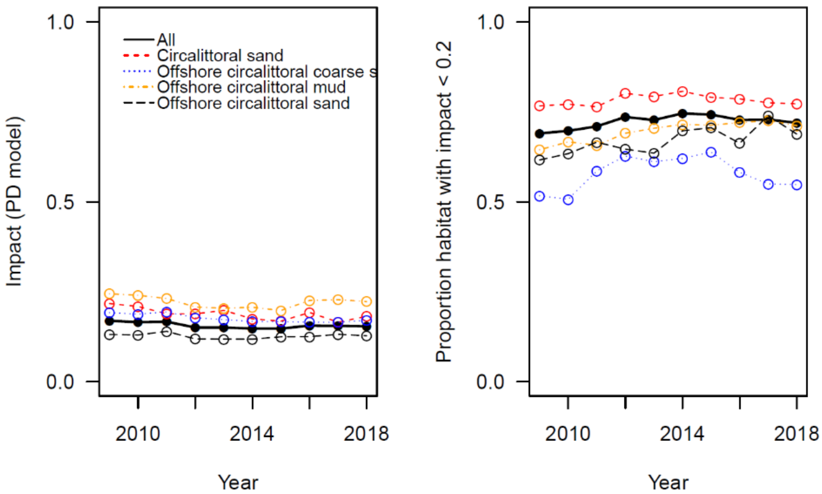

Figure 64: Time trends in Impact (Left panel) and state above a hypothetical threshold value (Right panel) overall and in each of the 4 most dominant habitat types in the Greater North Sea ecosystem fisheries (extracted from ICES WGFBIT 2019).

Alternative, semi-quantitative approaches including the JNCC BH3 method developed within the OSPAR region, and the cumulative Impact (BSII in HOLAS II) developed by HELCOM in the Baltic Sea (https://helcom.fi/helcom-at-work/projects/holas-ii/) were also considered.

Existing areas closed to bottom trawling under the Habitat and MSFD directives

Technical measures Regulation (EU) 1241/2019 and the Deep sea Regulation (Regulation (EU) 2016/2336) provide specifications for sensitive habitats protection. Previously, under the EU's Habitats and Birds Directives, Member States committed to develop and manage a coherent network of Marine Protected Areas within EU waters. A network of marine MPAs as then be implemented (Figure 65 also available at https://www.eea.europa.eu/themes/water/europes-seas-and-coasts/assessments/marine-protected-areas)

Many of them were designated to wrap so-called Reef habitats (Reefs has code H1170 in HD) made of animals forming biogenic reefs with specific marine species including in the North Sea: Polychaetes (e.g. *Sabellaria spinulosa, Sabellaria alveolata, Serpula vermicularis*), bivalves (e.g. *Modiolus modiolus, Mytilus* sp.) and cold water corals (e.g. *Lophelia pertusa*). Atlantic (Gulf of Cádiz): Madreporarians communities: *Dendrophyllia ramea* community (banks), *Dendrophyllia cornigera* community (banks); white corals communities (banks), (*Madrepora oculata* and *Lophelia pertusa* community (banks). *Solenosmilia variabilis* community (banks). Gorgonians communities: Facies of *Isidella elongata*, *Callogorgia verticillata* and *Viminella flagellum*; Facies of *Leptogorgia spp*.; Facies of *Elisella paraplexauroides*; Facies of *Acanthogorgia spp*. and *Paramuricea spp*. *Filigrana implexa* formations. Central Atlantic Islands (Macaronesian Islands): warm water corals (*Dendrophilia, Anthiphates*), serpulids, polychaetes, sponges, hydrozoan and briozoan species together with bivalve molluscs (*Sphondillus, Pinna*). Baltic Sea: Bivalves (e.g. *Modiolus modiolus, Mytilus* sp., *Dreissena polymorpha*). Mediterranean: Serpulid polychaetes, bivalve molluscs (e.g. *Modiolus sp. Mytilus sp*. and oysters). Polychaetes (e.g. *Sabellaria alveolata*).

In the Mediterranean, *Posidonia* beds (code H1120 in HD) are priority areas and many Natura 2000 sites have been designated to protect them. *Posidonia* beds provide important ecological functions and services and harbour a highly diverse community, with species of economic interest.

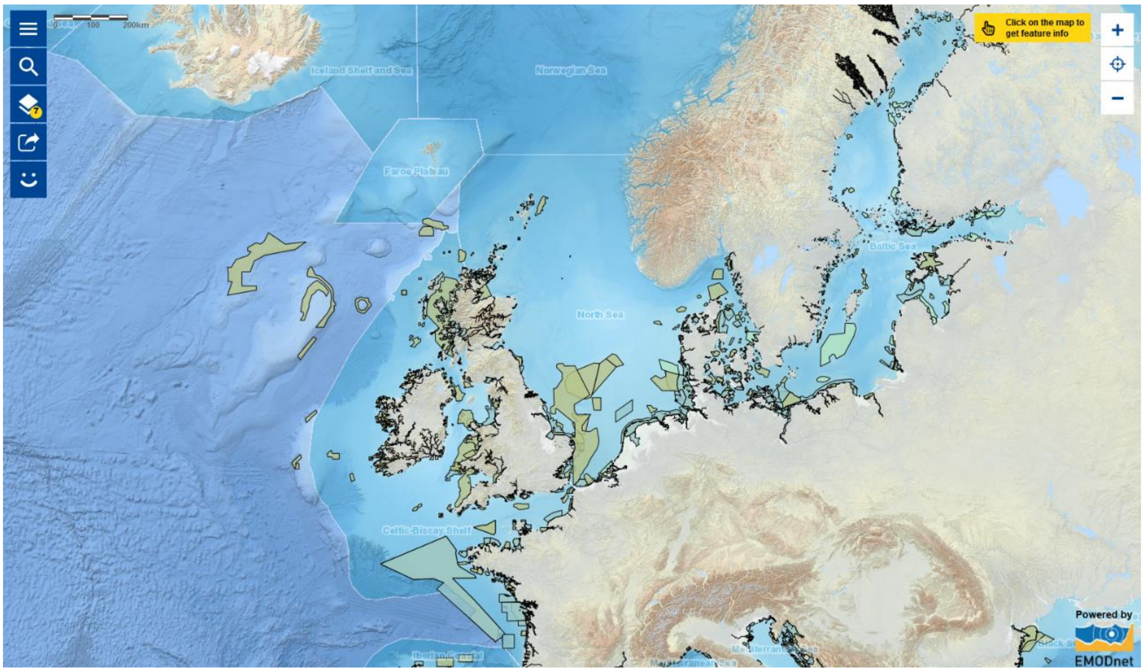

Figure 65: NATURA 2000 sites referred in the European Atlas of the Seas

The Report on the implementation of the Marine Strategy Framework Directive of May 2020 recognized that many of the European marine protected areas are still not properly managed and cannot be assessed in terms of coherence and effectiveness due to the lack of appropriate instruments and data flows. Hence, many conservations areas could be considered as "paper parks". Additionally, Europe's MPA network is not yet ecologically representative as ideally MPAs must cover a representative proportion of the habitats present in a region (EEA, 2019). Primarily, some deeper sea habitats are not included within the network.

As the Habitats Directive and MSFD are implemented at a national scale, the areas are designated inside the territorial waters of EU Member States. Cross-boundary protected areas need to be implemented through international coordination. Hence the TMR lists closed areas for both protecting fish and for protecting sensitive habitats across boundaries between EU and non-EU waters. The closed areas for sensitive habitats should be coherent with the MSFD target to reach Good Environmental Status (GES) by 2020 (Art. 4(c) in TMR). To date, there are only a few examples of implementation of areas in EU waters specifically designated to protect the benthic communities and sensitive habitats from fishing (as referred in Art. 12 in the TMR):

1. Closed areas that are listed in Annexe II of the TMR designating 5 areas in NWW and 3 areas in SWW where bottom trawls or similar towed nets, bottom set gillnets, entangling nets or trammel nets and bottom set longlines are prohibited.

2. Closed areas are listed in Annexe XII of the TMR, and complement the deep-seas regulation (Regulation (EU) 2016/2336) by banning trawling on VMEs. These focus on the NEAFC Regulatory Area. The TMR Annex XII Part D refers to the NEAFC regulatory area and defines closed areas for the protection of sensitive habitats. ("It shall be prohibited to conduct bottom trawling and fishing with static gear, including bottom set gillnets and bottom set longlines, within" 24 closed areas).

Most of the closed areas in the TMR are dedicated to protecting fish and juvenile and adult aggregations of fish (listed in Annexe V per region), offshore or within the coastal strip defined in the Regulation. Additional closed areas are defined in EU fisheries Multi-Annual Plans (Baltic, North Sea, NWW and West Med MAPs) with the same purpose.

Joint Recommendations that propose new areas for protection can be submitted by Regional Groups of Member States at any time (Art 17 of the TMR). These are then evaluated by STECF based on supporting evidence and best available scientific knowledge. These proposals areonly suggestions for closed or restricted areas to protect juveniles and spawning aggregations.

The Deep sea regulation requires the creation of an inventory of VMEs by the beginning of 2018 based on detection of VMEs occurrence. Art 9(6) stipulates that the Member States shall use the best available scientific and technical information, including biogeographical information and the information from fishing vessel reports encountering VMEs to identify where VMEs are known to occur or are likely to occur.

The Commission requires a competent scientific advisory body n to carry out an annual assessment of areas where VMEs are known to occur or are likely to occur. New impact assessments are required if there are significant changes to the techniques and gears used for bottom trawling, or where there is new scientific information indicating the presence of VMEs in a given area (Deepsea Reg Art 9 (8)). Building on recent efforts (2018 Advice and 2019 WKREG), ICES WKEUVME has established a draft workflow, with respective criteria for future area selection, that has been reviewed by the Working Group on the Ecosystem Effects of Fishing Activities (WGECO).

Potential management measures

Sensitive species

FAO lists (2019a) possible means and methods and guidelines to reduce marine mammal mortality in fisheries. The techniques for preventing or minimizing bycatch of marine mammals in capture fisheries was categorized as time-area closures; acoustic deterrents; modifications to fishing gear; changes in fishing operations or other strategies.

Time-area closures restrict fishing within a fishing zone, permanently or for a set period (FAO, 2011). In terms of bycatch mitigation, a range of spatial management categories exist from strict "no-take areas" which prohibit all fishing, to areas where only certain fishing gear or modified gear is permitted (i.e., area-gear closures), during certain periods of the year. Time area closures, if located in the most critical habitats and well designed, can reduce bycatch within their borders. However, their efficiency relies on the degree to which the mammals utilise the closed areas and the effects of possible effort displacement. Redirecting fishing effort to other surrounding areas may pose a risk of concentrating fishing effort into smaller or more densely fished areas that might result in a total higher bycatch than in the absence of time-area closures.

Acoustic deterrents refer to a range of devices that emit sound using electrical or mechanical means, or are designed to be acoustically reflective to echolocating cetaceans. Many acoustic deterrent devices have shown to decrease bycatch of marine mammals. They are deployed on or near to fishing gear, and include categories referred to as pingers, acoustic harassment devices, passive acoustic devices, and seal-scarer devices. Cetaceans and pinnipeds show behavioral responses to acoustic signals, mainly avoidance behaviour, although it is dependent on the species involved, underwater conditions that influence sound propagation, the type of acoustic device used, and the frequency and magnitude of the sound. There is concerns that animals might become sensitized to sound or being excluded from critical habitats which need to be taken seriously. Furthermore, high output devices may affect marine mammal hearing and potentially impact their survival. Reduction of harbour porpoise bycatch using pingers is effective. The Regulation requirement to use pingers only on vessels of ≥12m overall length, means that the part of the fleet that contribute the greatest proportion of cetacean bycatch are not required to mitigate bycatch. Vessels falling within the requirements are also limited by specification of gear characteristics (e.g. mesh sizes, net lengths) and the periods in which they fish; requirements to use pingers should not be constrained by such parametres.

Fishing gear may be modified to reduce interactions with marine mammals or to facilitate animals to self-release when they become hooked or entrapped. There are many physical modifications, some of which have been tested and others are used but not adequately studied. In trawl fisheries with marine mammal bycatch, excluder devices with escape openings (holes) through which these animals can exit the net after becoming entrapped is an example of fishing gear modifications. Another example of gear modification used for small cetaceans caught in bottom-set, midwater or driftnet gillnet fisheries is tie-down nets. Tie-down nets may reduce bycatch of these animals. Tie-downs are lines that are shorter than the height of the fishing net, and its terminal ends are attached to the float line and lead line at equal horizontal distances along the net. Tie-downs reduce the profile of the gillnet and create a more curved net shape vertically. Nets have also been modified with barium sulfat to increase its acoustic visibility to echolocating cetaceans to decrease bycatch. However results from studies have been non conclusive.

Change in fishing operation can cause decrease in bycatch. However, many measures outlined in guidelines and codes of practice are difficult to enforce and often rely heavily on voluntary adoption by the fishing industry. One example is Icelandic fisheries where fishermen decreased their soaktimes for gillnets to adapt to marketing demands of fresh fish. Another change of fishing operation can be to haul longlines faster to decrease depredation and bycatch by birds and marine mammals.

Where solutions to marine mammal bycatch seem limited, changing the type of gear used in a fishery to one that maintains commercial viability but pose less risks to marine mammals is an option. Longlines has been suggested as an alternative to bottom-set gillnets. Generally, differences in catch amount, species composition, and size selectivity occur between gillnets and longlines. However, during certain time periods and in certain areas longlines have shown to give comparable catches to gillnets. Fishing with pots potentially eliminates bycatch, and at the same time produce comparable catches to traditional gillnets. Although trawl nets do catch cetaceans in various parts of the world, the mortality is much lower than in gillnets. Seine nets are also considered to eliminate bycatch of marine mammals and are on trial in the Baltic as an alternative to gillnets. Generally, the gear types that catch less sensitive species impact the bottom habitats more.

At present, very little is implemented in terms of technical measures to protect sensitive species and habitats and to monitor the development in the risk, fisheries pose to these. A possible way to address this is to limit risky gears on core population distribution areas where these are known. Exceptions to this can be made where monitoring demonstrates either historic or current bycatch rates are below specified levels. Unfortunately, knowledge of the population distribution is often poor for rare species and even for less rare species, while dynamic changes in distribution are usually not monitored. In this case, it may be necessary to limit high risk gears in larger areas to ensure that fisheries do not pose a risk to sensitive species and habitats.

Sensitive habitats

Recent projects such as FP7 BENTHIS and SANOBA EASME EAFM have investigated whether technical gear modifications that lower gear penetration depth can potentially improve benthic status. As a component of this, it is assessed how a change in gear specification may affect catch efficiency. Among these technical solutions, the following have been highlighted as gear types with the potential to reduce benthic impact per kg landed fish compared to traditional trawls:

1. Electric Pulse- trawl
2. Semi-pelagic trawl doors lifting the otter boards from the seabed and reducing the benthic impact (McHugh et al. 2015)
3. Benthos release panels (BRPs, Fonteyne & Polet 2002; Revill & Jennings 2005) release large amounts of unwanted benthos and debris, which can decrease mortality on these animals and ease the onboard sorting process aboard demersal beam trawlers (e.g. Soertaert et al. 2016)
4. Raised footrope trawls which raise part of the gear from the seabed as used in the Celtic Seas to reduce bycatch of cod can reduce seabed impacts (He 2007; Winger et al. 2018).
5. ICES WKING report (2020) listed gear modifications that have been developed and implemented. Some address concerns on the impact on benthos communities:
    1. Soft brush groundgear had 63 % less linear bottom contact than conventional groundgears with no effect on target catches and limited effect on bycatch (tested in Australia, Broadhurst et al 2015, McHugh et al 2020). There is likely to be reductions in drag.
    2. Electro razor dredge exhibits a better selectivity for razor clams, reduced bycatch and much less habitat impact but illegal on EU legislation (Breen et al. 2011, Fox et al 2019)

Area restrictions and/or permanent closures prohibiting the use of certain fishing practices or gear designs is another management option for reducing the impact on habitats. The performance of technical measures (gear modifications or closed areas) for habitat protection (protecting vulnerable species and habitats) require evaluation. Most of the closed areas implemented in the CFP are seasonal closures to protect exploited stocks and life stages (juveniles, spawning aggregation, dependent predators), and not to protect benthic habitats. However, STECF SGMOS 2014 recognized that there is a growing number of areas designed to protect habitats and non-commercial fish species, e.g. Darwin Mounds, Rockall (vulnerable habitats) and the Northeast UK sandeel closure areas (dependent predators).

Current WGFBIT and WGBEC approaches focus on raising the effects observed in local empirical studies to the whole of an ecoregion. Local empirical studies are necessary to ground-truth such assessment outcomes. Rigorous pilot studies are needed for assessing the performance of potential technical measures to minimize fishing impacts on sensitive habitats. Ideally, the studies should apply B(efore)A(fter)C(ontrol)I(mpact) design to provide evidence of the effect of closed or restricted areas on the vulnerable marine habitats (see recommendations in STECF SGMOS 2007, see also Molland et al. 2013 for an example of BACI design). Unfortunately, most demonstrations rely on assessment designs that confound pre-existing differences with a significant effect (i.e. only applying Control-Impact). STECF SGMOS 2007 listed the possible confounding factors:

- Trends in fleet structure through, for example, vessels switching from gears restricted or banned in the closed areas to gears that target other stocks but can still directly/indirectly affect the stocks on which the closed areas is focused: creeping technical/effort shifts, particularly those related to the impacts of derogations in the closed areas, smaller, less powerful vessels allowed to fish, vessels from individual member states allowed to fish or gain earlier access or related to changes in market conditions, technological developments, etc.
- Trends in the behaviour of the fleets related to the closed areas, e.g. the impacts of 'fishing the edge';
- Impacts of displaced effort on the target stocks of the closed areas and for other target stocks, recognizing that effort displacement arguably applies to any restrictions on fishing;
- Impacts of illegal fishing;
- Impacts of broader scale technical regulations, effort reduction, etc.;
- Environmental changes due to natural and other anthropogenic factors that affect the status and distribution of stocks. Environmental changes include compensation effects within the food web (e.g., species substitution), or within the fisheries, e.g. responses of fleets to closed areas in terms of their behaviour (changes in fishing patterns, effort displacement) and their structure (changes to the size and number of vessels and the gears they employ).

STECF SGMOS emphasized that it is not ideal to rely on data collection under the CFP'SDC-Map such as the International Bottom Trawl Survey (IBTS) and general stock assessments to monitor performance of closed areas. The closed areas assessments must rely on data gathered through other programmes. The data needed to evaluate closed areas is typically not at appropriate temporal (before-after closed areas to establish time series data) and spatial (focused on assessing effects across the boundaries of the closed areas) scales. For several closed areas, little or no 'baseline' (pre-closed areas) data could be found.

The CFP TMR Annex XII Part D referring to the NEAFC regulatory area**,** defines 14 closed areas for the protection of sensitive habitats, referred to as VMEs. The deep-sea regulation (Regulation (EU) XXX/, 2016) stipulates that deep-sea fishing activities (bottom trawling and fishing with static gear, including bottom set gillnets and bottom set longlines) are prohibited at depths greater than 800m, and if between 400 and 800m, should occur inside the historical footprint spatial extent. If there are VMEs present in the 0-400m, they are not currently protected. There are few technical measures in the CFP defined in the TMR that aim at minimizing the impact of fishing activities on seabed habitats outside the NEAFC regulatory area, either in terms of gear specifications or closed or restricted areas (listed in Annexe II of the TMR, and defined for NWW and SWW).

It appears that the areas closed under the 2019 technical measures regulation has been **effective in preserving some vulnerable ecosystems** located in deep-sea areas. The measures taken are straightforward in that they **prohibit the use of bottom contacting gears and some passive gears in these areas**. The monitoring through VMS onboard vessels should ensure compliance with these rules. The introduction of new areas to protect has been facilitated by the means of delegated acts (Art 29 in the TMR), based on Joint Recommendations submitted by the Regional Groups of Member States that are assessed by STECF to ascertain that sufficient scientific knowledge proving that an area would deserve protection. Additionally, **measures implemented to protect and rebuilt commercial stocks can indirectly reduce the impact on seabeds and protect marine ecosystems as the spatial footprint required to catch quotas** is reduced.

The **European network of MPAs** (marine Natura 2000 sites) is only located within territorial waters. However, **the protection of sensitive habitats requires designing cross-border areas, which is allowed for under the CFP**. The GES objective defined in the MSFD has yet to define quantitative targets and, therefore, **the measure of performance of the TM to contribute to reaching the environmental goals on benthic habitats (D6) is not possible**. Indeed, while methods for estimating the impacts exist, it appears to the EWG group that there are no methods available to set thresholds to define whether GES can be achieved. The 2017 Decision requires Member States to define certain threshold values at Union level rather than through regional structures (EC, 2020). Progress in setting threshold values for determining good environmental status has so far been slow, and there seems to be a reluctance to set ambitious levels, as that would prevent Member States from reaching good environmental status within the deadline established in the Directive (EC, 2020).

It appears that some seabeds are more sensitive than others to some fishing practices such as bottom trawling. Therefore, they are candidate areas for areas requirering further protection. ICES WGFBIT demonstrated **that the areas where most fishing effort is deployed are not necessarily where the impact of fishing is/will be the largest**. Mapping sensitive habitats inform on what areas to protect but not necessarily on areas that require further protection. This is because i) the impact depends on the type of fishing gear used (e.g., gear penetrating deep into the sediments are impacting, and, at the meantime, some of these gears could sweep a relatively smaller area in total per unit of effort or per unit of landed fish), and ii) it is often observed that the fishing is typically patchily distributed which is explained by unsuitable bottom types to trawling, regulatory rules (ban on the coastal strip), or occupation of the space by other uses.

The deep-sea regulation (EC, 2016) recognizes that some marine habitats such as VMEs should be protected from any bottom fishing. For other more commonly distributed habitats, lightly or heavily fished, it is necessary to combine the existing pressure with the sensitivity to deduce the magnitude of the impact and decide on areas that would require further effort in protection. To conserve the benthic habitats in a CFP context, the **prioritization** for selecting areas could be by:

1. Protecting **VMEs** or calculated risk of VMEs occurrences (for biodiversity preservation). As requested by art 9(4) of the deep-seas regulation, member States willing to deploy fisheries in the strip 400-800m deep should first identify VMEs in their historical footprint based on the best available scientific knowledge when submitting a request.

2. Protecting **unfished/untrawled areas.** Even if these are not suitable for bottom trawling at present, they may be so in the future if innovative gears are deployed.

3. Protecting **lightly fished areas but with high potential of recovery** of the benthic community toward an environmental carrying capacity (=> restoration)

4. Protect **heavily fished areas, but with high potential of recovery** toward environmental carrying capacity (i.e. resilient), but with a high risk of disturbing the fisheries and fisheries economic return (marginal contribution)

Additionally, other areas can be identified satisfying multiple objectives may be considered (climate resilience, habitats and sensitive species). Conservation areas may also consider tradeoffs with CFP socioeconomic objectives. Managers during WKREG expressed the need for additional information on the profitability and social concerns that would arise from management options considering the balance as much as possible between the key features we want to preserve, the enforcement costs, and the minimal impact on fisheries economics (e.g. see WKTRADE 2017, WKTRADE2 2019, WGFBIT 2019).

Selection of areas should also account for possible fishing effort displacement effects that would likely result from fishers trying to compensate for the loss of catch opportunities. Such **effort displacement should be minimised** in order to prevent redirecting the pressure toward previously unfished/lightly fished areas with unintended adverse consequences. In amending the pre-existing list of closed areas by selecting new areas, Article 12 of the TMR recalls that it should be given attention to the mitigation of harmful effects of the displacement of fishing activity to other sensitive areas. Based on this it is expected that a shift of fishing effort from the core to the peripheral grounds will result in a more considerable impact than a shift of effort from the peripheral to the core fishing ground (e.g. Jenning et al. 2012, Bastardie et al. 2020).

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7. Contact details of EWG-20-20 participants

[1] - Information on EWG participant's affiliations is displayed for information only. In any case, Members of the STECF, invited experts, and JRC experts shall act independently. In the context of the STECF work, the committee members and other experts do not represent the institutions/bodies they are affiliated to in their daily jobs. STECF members and experts also declare at each meeting of the STECF and of its Expert Working Groups any specific interest which might be considered prejudicial to their independence in relation to specific items on the agenda. These declarations are displayed on the public meeting's website if experts explicitly authorized the JRC to do so in accordance with EU legislation on the protection of personnel data. For more information: http://stecf.jrc.ec.europa.eu/adm-declarations

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8. List of Annexes

Electronic annexes are published on the meeting's web site on:
https://stecf.jrc.ec.europa.eu/web/stecf/ewg2002

List of electronic annexes documents:

- EWG-20-02 – Annex 1 - List of sensitive species, filename: *Sensitive_species_risk_to_gear.xlsx*

9. List of Background Documents

Background documents are published on the meeting's web site on:
https://stecf.jrc.ec.europa.eu/web/stecf/ewg2002

List of background documents:

EWG-20-02 – Doc 1 - Declarations of invited and JRC experts (see also section 7 of this report – List of participants)

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