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Scientific, Technical and Economic Committee for Fisheries (STECF)

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Monitoring of the performance of the Common Fisheries Policy (STECF-Adhoc-23-01)

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EWG-adhoc-23-01 report:

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1.1 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 deals with the monitoring of the performance of the Common Fisheries Policy.

1.2 SCIENTIFIC, TECHNICAL AND ECONOMIC COMMITTEE FOR FISHERIES (STECF) – Monitoring of the performance of the Common Fisheries Policy (STECF-adhoc-23-01)

This advice was provided to the Commission on 30th March 2023.

1.3 Background provided by the Commission

Article 50 of the Common Fisheries Policy (CFP; Regulation (EU) No 1380/2013 of the European Parliament and of the Council of 11 December 2013) stipulates: "The Commission shall report annually to the European Parliament and to the Council on the progress on achieving maximum sustainable yield and on the situation of fish stocks, as early as possible following the adoption of the yearly Council Regulation fixing the fishing opportunities available in Union waters and, in certain non-Union waters, to Union vessels."

1.4 Request to the STECF

STECF is requested to report on progress in achieving MSY objectives in line with the Common Fisheries Policy.

1.5 STECF observations

To address the agreed Terms of Reference, STECF expert group (STECF-Ad hoc-23-01) was convened between January and March 2023 to compile available assessment outputs and conduct the extensive analysis required to prepare the annual CFP monitoring report.

The expert group presented a comprehensive report accompanied by several detailed annexes to STECF PLEN 23-01 providing: 1) CFP monitoring protocols as agreed by STECF (STECF, 2018); 2) R code for computing NE Atlantic indicators; 3) R code for computing Mediterranean & Black Seas indicators 4) Exploratory indicators in the Mediterranean and Black Seas 5) Sensitivity analyses. The supporting electronic annexes include 1) URL links to electronic annexes referring to the reports and stock advice sheets underpinning the analysis; 2) ICES data quality issues corrected prior to the analysis; and 3) R code for computing all the European waters' indicators provided in the STECF PLEN 23-01 report. The report and electronic annexes are available at <https://stecf.jrc.ec.europa.eu/reports/cfp-monitoring>.

STECF notes that the report is clear and well laid out, comprehensively describing the analysis undertaken and cataloguing the changes made in the approach since the previous report (STECF-Ad hoc-22-01).

The STECF-Ad hoc-23-01 report sets out results of the analyses separately for the Northeast Atlantic (NE Atlantic) and the Mediterranean & Black Seas (Sections 3 and 4 respectively). Based on the above results, progress towards achieving MSY objectives are summarised below. In this report, "Northeast Atlantic" refers to stocks in FAO Area 27 inside and outside EU waters¹, and "Mediterranean & Black Seas" refers to stocks in FAO Area 37². Additionally, at the request of EUROSTAT, an overview for all stocks in European waters is also presented (Section 5 of the STECF-Ad hoc-23-01 report).

For the NE Atlantic (FAO area 27), the most recent published assessments carried out up to (and including) 2022 incorporating data up to 2021 were downloaded from the ICES website on 12 January 2023. For the Mediterranean & Black Seas (FAO area 37), the information was extracted from the STECF Mediterranean Expert Working Group repositories comprising the most recently published assessments carried out up to 2022 with data up to 2021, and from the GFCM stock

¹ The stocks that are included in the NE Atlantic analysis are those stocks in ICES category 1, 2 and 3 for which assessments are available and that were managed through a TAC at EU level in 2017 (based on DG MARE TAC/quotas database). This year all category 1 and 2 EU stocks that were dropped due to the absence of stock specific TACs in 2017 but for por.27.nea and rju.27.7de there was a TAC in place in 2022 were retained. Stocks in EU waters include stocks in/or partially in ICES areas 3, 4, 6, 7, 8 and 9, but excluding Norwegian coastal stocks in area 4 (see list of stocks in section 5; Scott et al., 2017a).

² The combinations of Species/GSA that are included in the Mediterranean & Black Seas analysis are those based on a ranking system approach for which the species having a rank in the first ten positions either in total live weight or total economic values between 2012 and 2014 were chosen (see Mannini et al., 2017).

assessment forms comprising the most recently published assessments carried out up to 2022 with data up to 2020.

STECF notes that among the new stocks added this year in the calculation of the indicators in the Mediterranean & Black Seas, there are three stocks based on quantitative biomass-based models that were not considered in previous years.

Trends towards reaching the MSY objective in the Northeast Atlantic and Mediterranean & Black Seas

The overview below describes the trends in fishing pressure observed in the NE Atlantic and the Mediterranean & Black Sea for the periods 2003 to 2021 and 2003 to 2020, respectively. It applies to the stocks with an analytical assessment and with associated reference points included in the reference list (sampling frame) of stocks for these areas.

Overview of stock status

Northeast Atlantic

The indicators provided in the STECF-Ad hoc-23-01 report show that in the NE Atlantic (both EU and non-EU waters), stock status has significantly improved since 2003 (Figure A) but that many stocks are still overexploited. Among the stocks which are fully assessed (Table 3, in the STECF-Ad hoc-23-01 report), the proportion of overexploited stocks (i.e., $F > F_{MSY}$, blue line) has decreased from around 74% (2003-2008) to 26% in 2021. The proportion of stocks outside safe biological limits ($F > F_{PA}$ or $B < B_{PA}$, yellow line, Table 5 in the STECF-Ad hoc-23-01 report), computed for the 47 stocks for which both reference points are available, follows a similar decreasing trend, from 81% in 2003 to 38% in 2021.

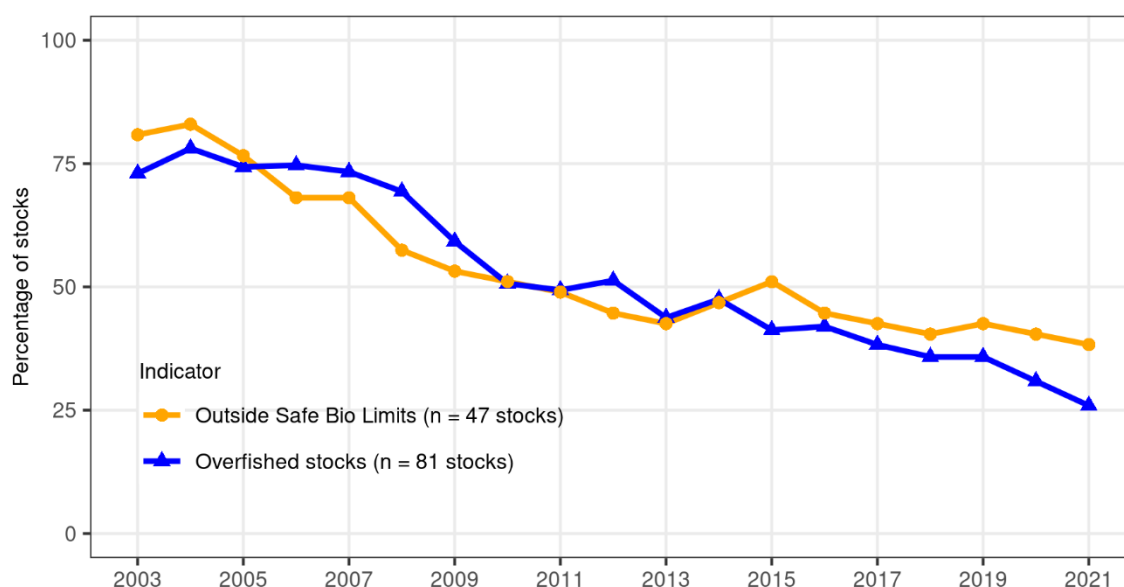


Figure A: Trends in stock status in the NE Atlantic (both EU and non-EU waters) 2003-2021. Two calculated proportions are presented: blue line: the proportion of overexploited stocks ($F > F_{MSY}$) (out of a total of 81 stocks) and yellow line: the proportion of stocks outside safe biological limits SBL ($F > F_{pa}$ or $B < B_{pa}$) (out of a total of 47 stocks).

Combining these two calculated proportions (Table A), STECF notes that in 2021, 5 stocks that are exploited below F_{MSY} are still outside safe biological limits, and 3 stocks inside safe biological limits are still exploited above F_{MSY} . In addition, 34 stocks have an unknown status with regards to safe biological limits. For the last known year, of the 81 stocks considered, only 32% (26 stocks) are

known to be neither overexploited nor outside safe biological limits, suggesting that the objective in Art. 2.2 of the CFP has not been met.

Table A: Number of stocks overfished ($F > F_{MSY}$), or not overfished ($F \leq F_{MSY}$), and inside ($F \leq F_{pa}$ and $B \geq B_{pa}$) and outside ($F > F_{pa}$ or $B < B_{pa}$) safe biological limits (SBL) in 2021 in the NE Atlantic (both EU and non-EU waters). Unknown SBL refers to stocks whose status regarding SBL could not be assessed.

	Below F_{MSY}	Above F_{MSY}
Inside SBL	26	3
Outside SBL	5	13
Unknown SBL	29	5

Mediterranean & Black Seas

For the Mediterranean & Black Seas, the number of stocks assessed and for which data is available, varies from year to year and assessment results for some stocks do not extend back to the early part of the time-series. However, STECF observes that the number of stock assessments available this year has increased considerably compared to last year (from 39 stocks in 2021 to 58 stocks in 2022). This is due to stock assessment results now being available publicly on the GFCM website through their STAR application³ in addition to available reports.

Additionally, biomass reference points are now available for 16 stocks, most of which were calculated during the Western Mediterranean stock assessment working group (EWG 22-09).

STECF notes that for most of these stocks $F_{0.1}$ was used as a proxy for F_{MSY} and consequently, the biomass at $F_{0.1}$ is used here as a proxy for B_{MSY} . As a result, the STECF-Ad hoc-23-01 report presents, for the first time, indicators on the number of overexploited stocks and on the number of stocks with F above F_{MSY} or SSB below B_{MSY} (annex 4 of the STECF-Ad hoc-23-01 report). Given the variation in the data availability from year to year, STECF considers these indicators are still exploratory. However, these results alongside existing information confirm that a large majority of the stocks remain overexploited (in 2021, 41 out of 57 stocks (72%) were overfished).

Trends in the fishing pressure (Ratio of F/F_{MSY})

As agreed by STECF (2018), STECF-Ad hoc 23-01 computed the trends in fishing pressure using a statistical model (Generalised Linear Mixed Effects Model, GLMM) accounting for the variability of trends across stocks and including the computation of a confidence interval around the median. STECF notes that a large confidence interval around the median arises from inconsistent temporal trends among the individual stock time series and the different level of fishing mortality relative to reference fishing mortality across stocks.

The model-based results for the NE Atlantic (inside and outside EU waters), Mediterranean and Black Seas and for all EU waters are displayed in Figures 9, 11, 20 and 26 of the STECF-Ad hoc-23-01 report. For illustration, trends in the median values for F/F_{MSY} are summarised in Figure B below over the time series for the NE Atlantic inside and outside EU waters and for the Mediterranean and Black Sea.

³ <https://www.fao.org/gfcm/data/star>

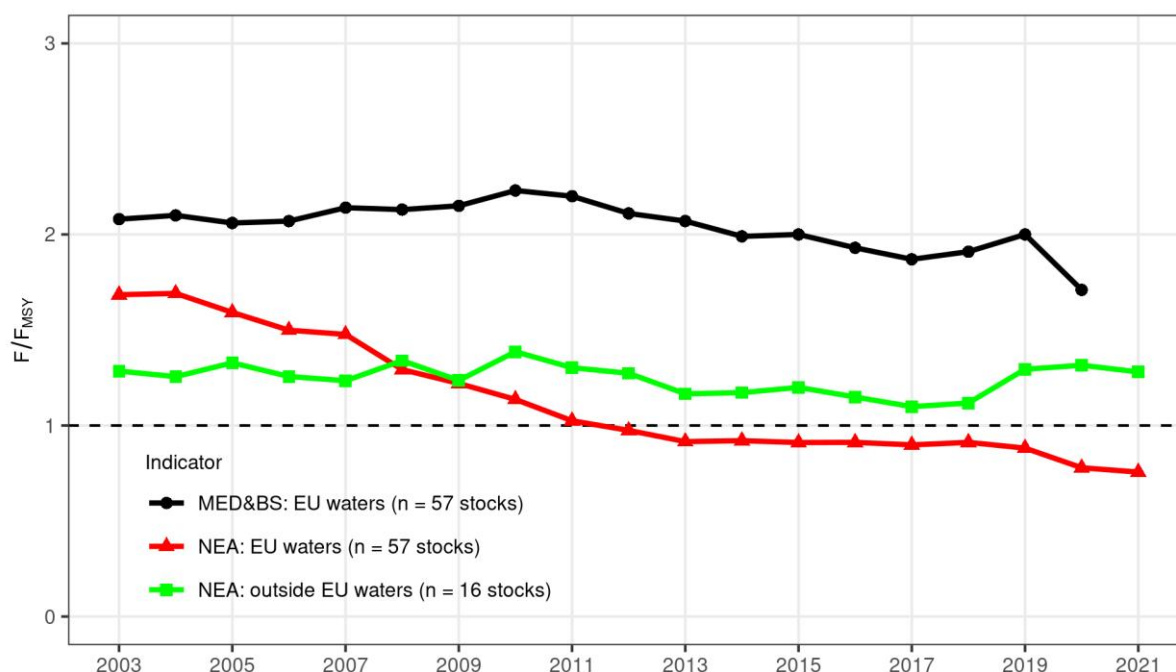


Figure B: Trends in fishing pressure 2003-2021. Three model-based indicators F/F_{MSY} are presented (all referring to the median value of the model): one for 57 stocks with appropriate information in the NE Atlantic EU waters (red line); one for an additional set of 16 stocks also located in the NE Atlantic but outside EU waters (green line), and one for the 57 stocks from the Mediterranean Sea & Black Seas (black line).

Northeast Atlantic

In the NE Atlantic EU waters, the model-based indicator of fishing pressure (F/F_{MSY} , based on 57 stocks with appropriate information – Figure 9 in the STECF-Ad hoc-23-01 report) shows a gradual downward trend over the period 2003-2021. In the early 2000s, the median of this indicator of fishing mortality was about 1.7 times larger than F_{MSY} , but this has reduced and stabilised close to slightly below 1 (F_{MSY}) over the period 2013-2019. STECF notes that the line being around 1 means that only around half of the stocks are fished below F_{MSY} . In 2021, the value reached its lowest value of 0.76.

The same model-based indicator was computed by STECF-Ad hoc-23-01 expert group for an additional set of 16 stocks located in the NE Atlantic, but outside EU waters (Figure 11 in the STECF-Ad hoc-23-01 report). The median indicator for these stocks has always remained above 1 (ranging from 1.1-1.4) since 2003, with no increasing or decreasing trend.

STECF notes that the differing perceptions compared to last year may be due to changes in the available stocks (see the sensitivity analyses provided in the annex 5 of the Ad hoc 23-01). Hence, the median estimates of the model-based indicator are likely to be revised from one year to the next and, therefore, should be interpreted with caution.

Mediterranean and Black Seas

The indicator for fishing pressure computed for stocks from the Mediterranean & Black Seas (57 stocks) has remained at a high level during the whole 2003-2020 time series ranging between 2.2 and 1.7 (Figure 20 in the STECF Ad hoc 23-01 report). STECF observes a decreasing trend in the proportion of overexploited stocks from 2019 to 2020 but STECF is not in the position to assess whether this change reflects a temporary decrease in fishing pressure, or whether this is a longer-term positive trend. While there appears to be a downward trend since 2011, the median value for F/F_{MSY} remains above 1.7 x F_{MSY} (Figure B), and hence, does not meet the maximum sustainable yield objective of the CFP.

EU Waters

At the request of EUROSTAT, the F/F_{MSY} model-based indicator was also fitted using all stocks in EU waters as input data, (i.e., for both the in NE Atlantic EU waters and in the Mediterranean & Black Seas together (114 stocks). The overall F/F_{MSY} indicator for all EU waters computed shows a decreasing trend over time but with values always above 1. Compared to previous years, the number of stocks corresponding to the NE Atlantic EU waters and to the Mediterranean & Black Seas was more balanced. However, the trend in indicator values (Figure 26 in the STECF-Ad hoc-23-01 report) appears to be driven by F/F_{MSY} estimates for stocks in the NE Atlantic. This is likely due to the significant variability in trends observed in Mediterranean and Black Seas stocks, compared to the more consistent trends observed across the NE Atlantic stocks. For this reason, STECF decided not to present the trend for EU waters as a whole in Figure B as it can be misleading in terms of monitoring the CFP, although it may be useful for EUROSTAT's reporting requirements.

Trends in Biomass

The model-based results for the NE Atlantic (EU waters), the Mediterranean and Black Seas and for data-limited stocks in the NE Atlantic (=ICES "category 3" stocks) are provided in Figures 13, 22 and 15 respectively of the STECF-Ad hoc 23-01 report. For illustration, trends in the median values for biomass over time are summarised in Figure C below. STECF notes there is large uncertainty around this indicator (see Figure 27 in the STECF-Ad hoc-23-01 report).

The model-based indicators for the trend in biomass (Figures 13 and 22 of the STECF-Ad hoc-23-01 report) show a general increase over time since 2007 in the NE Atlantic (EU waters only) for assessed stocks, whereas data limited stocks for which only a relative biomass index is available from scientific survey data, reach the highest value in 2015 followed by a decreasing trend until 2021 (Figure C). STECF notes that the change in the biomass trend for data limited stocks compared to last year is due to changes in the number of stocks used to compute this indicator. Despite the large uncertainty of this indicator, in 2021, biomass was on average around 40% (for assessed stocks) and 46% (for data limited stocks), higher than in 2003. In the Mediterranean & Black Seas, the median biomass was slightly higher at the beginning of the time-series, but declined and remained stable from 2011–2013, after which it shows a gradual increase.

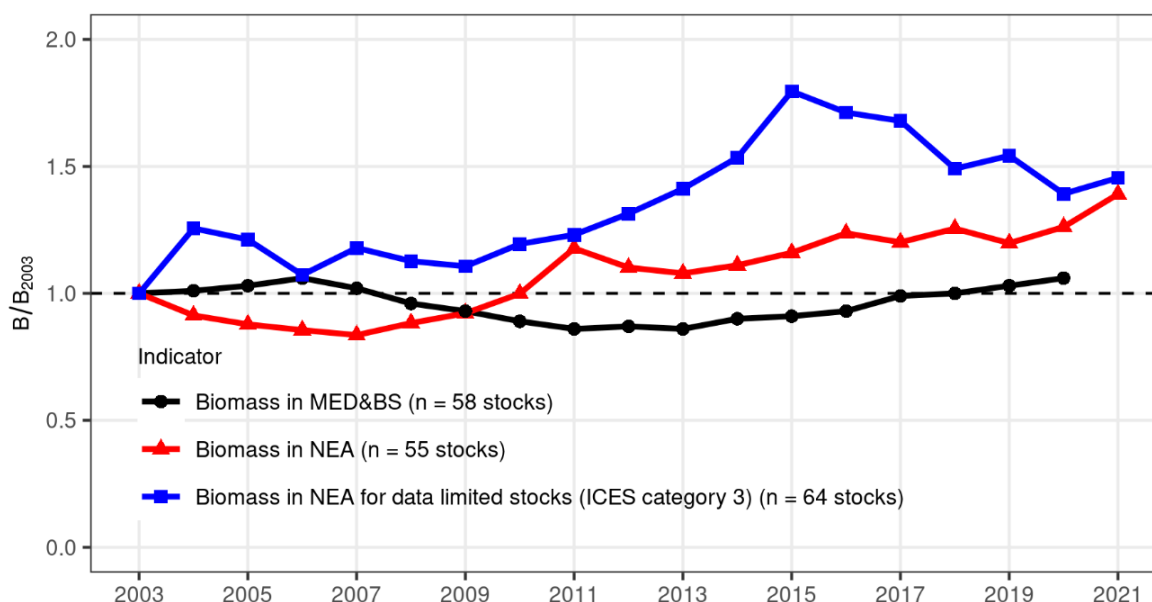


Figure C: Trends in the indicators of stock biomass (median values of the model-based estimates relative to 2003). Three indicators are presented: one for the NE Atlantic EU waters (55 stocks considered, red line); one for the Mediterranean & Black Seas (58 stocks, black line); and one for data limited stocks in NE Atlantic (ICES category 3, 64 stocks, blue line).

Trends in Recruitment

The model – based results for the trend in decadal recruitment are given in Figure 16 in the STECF-Ad hoc-23-01 report. This indicator aims to identify long-term trends of recruitment for all stocks and is calculated over a twenty-year moving average: For example, the decadal recruitment for 2019 for a single stock is the ratio between the average recruitment from 2010 to 2019 over the average recruitment from 2000 to 2009 (check the protocol in Annex 1 of the STECF-Ad hoc-23-01 report for more details). This indicator is subject to high year-on-year variability. The model output median values is displayed in Figure D below. The average decadal recruitment indicator shows a decreasing trend until 2012 and an inversion afterwards.

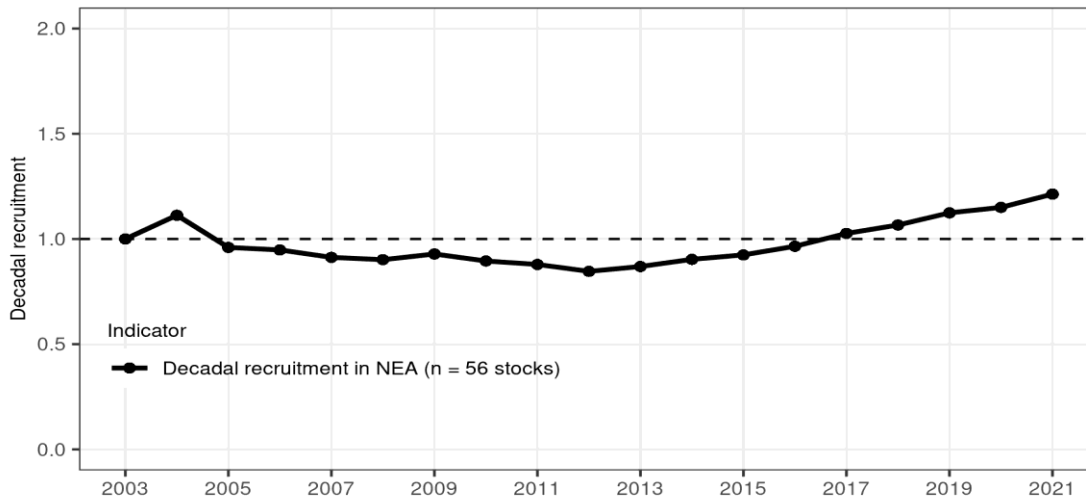


Figure D: Trend in median values for decadal recruitment scaled to 2003 in the NE Atlantic area (based on 56 stocks).

Trends per Ecoregion

The STECF-Ad hoc-23-01 report provides indicator trends by Ecoregion for EU waters in the NE Atlantic and the Mediterranean & Black Sea. However, STECF notes that the number of stocks contributing to each ecoregion is generally rather small (<10 stocks per region) meaning that the indicator values may be imprecise and, therefore, should be interpreted with caution.

In EU waters, the overall fishing pressure in all ICES Ecoregions has decreased and the status of stocks has improved compared to the start of the time-series (Figures 4 and 10 in the STECF-Ad hoc-23-01 report). The modelled estimate of the F/F_{MSY} ratio for 2021 was between 0.48 and 0.95 corresponding to the Bay of Biscay and Iberian Eco-Region and the Baltic Sea EcoRegions respectively. Accepting the inherent imprecision in the indicator, for the stocks analysed, the trends give a clear signal that fishing pressure in each region has reduced over the time-series.

In the Mediterranean & Black Sea, the fishing pressure has been stable in the Central Mediterranean Ecoregion, while it has decreased steadily in the Western Mediterranean Ecoregion. However, the recent decreasing patterns in the Eastern Mediterranean Sea and in the Black Sea are both based on only four stocks and, therefore, the trend should be interpreted with caution. The modelled estimate of the F/F_{MSY} ratio for 2021 was above 1.7 for all the EcoRegions.

Historical performance

STECF notes that the trends in fishing pressure and biomass observed in this year's STECF-Ad hoc-23-01 report differ from previous STECF reports. Changes of historical perceptions over time (Section 7 of the STECF-Ad hoc-23-01 report) show that in the Northeast Atlantic from 2017 to 2021 there's a tendency to underestimate F/F_{MSY} when compared to the previous year's estimate, and, conversely, overestimate B/B_{2003} . That pattern seems to have changed for F/F_{MSY} in 2022 and 2023 (Figures 28 and 29 in the STECF-Ad hoc-23-01 report).

In the Mediterranean and Black Seas, there appears to be no systematic under- or over-estimation observed in the historical pattern (Figures 30 and 31 in the STECF-Ad hoc-23-01 report). Beyond the issue of the varying number of stocks from year to year, such differences may be partially attributable to the results from updates of the stock assessments with the addition of additional

years of data or changes in the assessment methodology. Therefore, small differences in the resulting outcomes compared to last year's report should not be over-interpreted as positive or negative.

Coverage of the scientific advice

Coverage of biological stocks by the CFP monitoring

The analyses of progress in achieving the MSY objective in the NE Atlantic should include all stocks with advice provided by ICES that are at least partially inside EU waters. According to the ICES database accessed for the analysis, ICES provided scientific advice for 220 biological stocks included in EU waters (at least partially). Of these, 101 stocks (46%) are data limited (ICES category 3 and above, Table B).

Table B: Total number of stocks assessed by ICES for different stock categories in different areas. Note that not all of these stocks are considered of EU relevance (STECF 15-04). Therefore, the numbers are higher than those used in the CFP monitoring analysis.

	ICES Stock Category						Total
	1	2	3	4	5	6	
Arctic Ocean	8	0	3	0	0	0	11
Azores	0	0	2	0	1	0	3
Baltic Sea	9	1	4	0	0	0	14
BoBiscay & Iberia	14	5	14	0	2	4	39
Celtic Seas	26	2	14	2	7	1	52
Greater North Sea	26	2	22	3	4	1	58
Iceland, Greenland and Faroes	17	1	6	0	0	0	24
Widely	7	1	9	0	2	0	19
Total	107	12	74	5	16	6	220

The present CFP monitoring analysis for the NE Atlantic is focused on stocks with a TAC in 2017 and for which estimates of fishing mortality, biomass and biological reference points are available. As detailed in the STECF-Ad hoc-23-01 report, not all indicators can be calculated for all stocks in all years. The ad hoc group was able to compute indicators for 31 to 81 of category 1 and 2 stocks depending on indicators, years and areas, and 64 category 3 stocks (Table 2 in the STECF-Ad hoc-23-01 report). Such stocks represent a large share of catches, but there is still a significant number of biological stocks present in EU waters that are not included in the sampling frame of the CFP monitoring analysis.

In the Mediterranean and Black Seas region, stock status and trends are only assessed for a limited number of stocks. The expert group selected 243 combinations of Species/GSA in the sampling frame (Mannini et al., 2017), of which 96 combinations (39%) have been covered by 58 available stock assessments conducted between 2020 and 2022. The difference between the number of combinations (96) and the number of stock assessments (58) stems from the fact that some stocks are assessed over multiple GSAs. STECF notes that, despite this year's increase in the number of stocks available, there is still a need to increase the coverage of stocks in the CFP monitoring analysis to increase the representativeness of the indicator values for the Mediterranean and Black Seas.

Coverage of TAC regulation by scientific advice

STECF notes that 158 TACs (combination of species and fishing management zones) in the EU waters of the NE Atlantic are derived using the agreed sampling frame (Gibin, 2017; Scott et al 2017a, Scott et al 2017b) with two additional TACs added this year. STECF underlines that in many cases, the boundaries of the TAC management areas are not aligned with the biological limits of stocks used in ICES assessments. Therefore the ad hoc group computed an indicator of advice coverage, where a TAC is "covered" by a stock assessment when at least one of its divisions match

the spatial distribution of a stock for which reference points have been estimated from an ICES full assessment. Based on this indicator, 51% of the 158 TACs are covered, at least partially, by stock assessments that provide estimates of F_{MSY} (or a proxy), 40% by stock assessments that have B_{PA} , with 24% covered by stock assessments that provide estimates or proxies of B_{MSY} .

Additionally, STECF notes that, using this index, some TACs can be considered as “covered” if they relate to: (i) part of a given management area, (ii) several assessments contributing to a single TAC (e.g., *Nephrops* functional units in the North Sea) or (iii) scientific advice covering a different (but partially common) area (e.g. whiting in the Bay of Biscay). Such an approach overestimates the spatial coverage of advice (i.e., the proportion of TACs based on a single and aligned assessment) and means that many TACs are still not covered by scientific advice based on F_{MSY} reference values.

Ongoing developments

STECF acknowledges that monitoring the performance of the CFP requires significant effort to provide a comprehensive picture of progress towards the CFP objectives. The process presents several methodological challenges due to the annual variability in the number and categories of stocks assessed as well as the large variation in trends across stocks. As a result, the choice of indicators and their interpretation is regularly discussed, expanded, and adjusted by STECF when necessary.

To ensure consistency in the indicators across years, STECF observes that the guidelines for inclusion/exclusion of stocks for the calculation of indicators needs to be updated in the CFP monitoring protocol. Additionally, STECF notes that there is an increase in the number of stocks assessed with biomass-based dynamic models, both in the NE Atlantic and in the Mediterranean and Black Seas. Their impact in the calculation of indicators has not been fully evaluated and should be further considered in any potential revision of the protocol.

STECF notes that the process to discuss and update the current protocol was initiated in 2022 (STECF PLEN 22-01, STECF PLEN 22-03). The changes to the presentation of results agreed during STECF PLEN 22-03 have already been incorporated into this year’s CFP monitoring report. However, additional work is still needed on issues such as the sampling frames definition, sensitivity of the results to available stocks, potential changes to the modelling approach, analyses of historical robustness and the development of indicators for all EU stocks.

STECF also recognises the need to broaden the scope of the CFP monitoring report to address those CFP objectives that are not currently dealt with. In particular, indicators covering selectivity, the landing obligation, the wider ecosystem, and socio-economic aspects in the analysis would be a useful expansion. A process to develop such indicators was initiated in 2018 by EWG 18-15 but further work is needed to progress these indicators. STECF is ready to carry out this work if requested to do so.

1.6 STECF conclusions

Regarding the progress made in the achievement of F_{MSY} in line with the CFP, STECF concludes that the latest results indicate a reduction in overall fishing mortality and a general increase in stock biomass in the NE Atlantic over the period 2003-2021. Nevertheless, several stocks remain overfished and/or outside safe biological limits. The objective of the CFP, which aimed to ensure that all stocks are fished at or below F_{MSY} since 2020, has not been achieved for these stocks.

STECF concludes that the situation with regards to stocks in the Mediterranean and Black Sea remains challenging, with annual fishing mortality estimates around two times above F_{MSY} over the full time-series (2003-2020). However, there are indications that fishing pressure has decreased since 2013 while biomass has shown a slight improvement since 2011, being above the 2003 reference level in the last two years (2019-2020).

STECF concludes that many stocks still lack definition of some key reference points (B_{PA} , F_{PA} , F_{MSY} or B_{MSY}). STECF acknowledges the advances made in the last year in increasing the number of stocks included in the analysis and supports ongoing work in ICES, GFCM and STECF EWGs to increase the number of stocks with key reference points further. Any progression on this issue will be incorporated into future CFP monitoring reports as new information becomes available.

STECF concludes that there is a need to revise and update the protocol that has been followed for this monitoring report since 2018. The protocol would benefit from broadening its scope to consider possible additional CFP objectives not currently dealt with.

1.7 Contact details of STECF members

¹ - Information on STECF members' affiliations is displayed for information only. In any case, Members of the STECF shall act independently. In the context of the STECF work, the committee members do not represent the institutions/bodies they are affiliated to in their daily jobs. STECF members 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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REPORT TO THE STECF

EXPERT WORKING GROUP ON MONITORING THE PERFORMANCE OF THE COMMON FISHERIES POLICY (EWG-ADHOC-23-01)

Virtual meeting, January-March 2023

This report does not necessarily reflect the view of the STECF and the European Commission and in no way anticipates the Commission's future policy in this area

1 INTRODUCTION

Article 50 of the EU Common Fisheries Policy (Regulation (EU) No 1380/2013) states:

“The Commission shall report annually to the European Parliament and to the Council on the progress of achieving maximum sustainable yield and on the situation of fish stocks, as early as possible following the adoption of the yearly Council Regulation fixing the fishing opportunities available in Union waters and, in certain non-Union waters, to Union vessels.”

To fulfil its obligations to report to the European Parliament and the Council, each year, the European Commission requests the Scientific, Technical and Economic Committee for Fisheries (STECF) to compute a series of performance indicators and advise on the progress towards the provision of article 50.

In an attempt to make the process of computing each of the indicators consistent and transparent and to take account of issues identified and documented in previous CFP monitoring reports, a revised protocol was adopted in 2019 (Annex 1).

An ad hoc Expert Group comprising experts from the European Commission’s Joint Research Centre (JRC) was convened from January to March 2023 to compute the performance indicator values according to the agreed protocol (Annex 1) and to report to the STECF plenary meeting scheduled for 20-24 March 2023.

1.1 Terms of Reference for the ad hoc EWG-23-01

The Expert Group is requested to report on progress in achieving MSY Objectives in line with CFP.

2 DATA AND METHODS

2.1 Data sources

The data sources used are referring to coastal waters of the EU in FAO areas 27 (North East Atlantic and adjacent seas) and 37 (Mediterranean and Black Seas). The Mediterranean included FAO Geographical SubAreas (GSA) 1, 5, 6, 7, 8, 9, 10, 11, 15, 16, 17, 18, 19, 20, 22, 25, and 29. The NE Atlantic included the ICES subareas "3", "4", (excluding Norwegian waters of division "4.a"), "6", "7", "8", "9", and "10".

2.1.1 Stock assessment information

From mid-March 2020, the Covid-19 outbreak prevented the ICES Expert Working Groups to meet physically. The "spring 2020" approach (<https://www.ices.dk/news-and-events/news-archive/news/Pages/spring2020approach.aspx>) was applied neither in 2021 nor 2022 and advice sheets were back to their original format. The CFP monitoring report 2021 (STECF, 2021a) was the only report based primarily on abbreviated advice sheets. In this report, category 3 stocks bli.27.22-32 and dab.27.22-32 were given an abbreviated advice covering 2021, 2022 and 2023.

For the NE Atlantic (FAO area 27), the information was downloaded from the ICES website (<https://standardgraphs.ices.dk>) on 12 January 2023, comprising the most recent published assessments carried out up to and including 2022. Thorough data quality checks and corrections were carried out to ensure the information downloaded was in agreement with the summary sheets published online (online Annex 1 and 2, <https://stecf.jrc.ec.europa.eu/reports/cfp-monitoring>).

For the Mediterranean region (FAO area 37), the information was extracted from the STECF Mediterranean Expert Working Group repositories (<https://stecf.jrc.ec.europa.eu/reports/medbs>) comprising the most recent published assessments carried out up to 2022 and from GFCM stock assessment forms (<https://www.fao.org/gfcm/data/star/en/>) comprising the most recent published assessments carried out up to 2022.

The table reporting the URLs for the report or advice summary sheet for each stock is available online (online Annex 1, <https://stecf.jrc.ec.europa.eu/reports/cfp-monitoring>).

2.1.2 Management units information

For the NE Atlantic, management units are defined by Total Allowable Catches (TAC). Annual fishing opportunities for a species or a group of species in a Fishing Management Zone (FMZ). The information regarding the TACs in 2016 was downloaded from the FIDES reporting system. Subsequently, this information was cleaned and processed to identify the FMZ of relevance to this work, as well as the ICES rectangles they span to (Gibin, 2017; Scott et al., 2017a; Scott et al., 2017b). This work was done once in 2017 and has not been updated since. Nevertheless, this year all category 1 and 2 EU stocks dropped due to the absence of stock-specific TACs in 2017 were manually checked to assess whether in 2022 there was a TAC in place, in which case they were added in the analysis. EU category 1 and 2 skate and ray stocks managed as a stock complex under a combined TAC were not included in the analysis.

2.1 Methods

The methods applied and the definition of the sampling frames followed the protocol (Jardim et al., 2015) agreed by STECF (2016) and updated following the discussion in STECF (2018). The updated protocol is presented in Annex 1 and the R code used to carry out the analysis in Annex 2 for the Northeast Atlantic and Annex 3 for the Mediterranean and Black Seas.

2.2 Points to note

- Stocks assessed with biomass dynamic models do not provide a value for F_{PA} although they may provide a B_{PA} proxy ($0.5 \cdot B_{MSY}$). Consequently, such stocks cannot be used to compute Safe Biological Limits (SBL; Section 3.2.2)
- The Generalised Linear Mixed-effects Model (GLMM) uses a shortened time series, starting in 2003, instead of the full time series of available data. This has the advantage of balancing the dataset by removing those years with only a low number of assessment estimates. It has the disadvantage of excluding data.

- Indicators of trends computed with the GLMM show the average progress of the process they represent, including its uncertainty in terms of 50% and 95% confidence intervals. In the former case corresponding to the range between 25% and 75% percentiles, and for the latter between 2.5% and 97.5% percentiles.
- The GLMM fit within the bootstrap procedure does not converge for all samples. Worst case is the Biomass trends model fit with approximately 7% non-convergence. Failed resamples were excluded when deriving model-based indicators.
- The biomass indicator for stocks assessed with data-limited methods (ICES stock category 3) includes both abundance and biomass indices, with a variety of measurement units.

2.3 Differences from the 2022 CFP Monitoring Report

2.3.1 Northeast Atlantic and adjacent seas

The methods used in the analysis for this report were the same used for the 2022 report (STECF, 2022a).

Compared to last year's analysed dataset, with relation to category 1 & 2 EU stocks:

- 7 stocks were added
 - ple.27.24-32 (upgraded to category 2)
 - ank.27.78abd (upgraded to category 1)
 - hke.27.8c9a (upgraded to category 1)
 - cod.27.7a (upgraded to category 1)
 - por.27.nea (upgraded to category 2 with 0 TAC)
 - rju.27.7de (upgraded to category 2 with TAC)
 - nep.fu.3-4 (5 years available for the first time)
- 1 stock was dropped
 - had.27.6b (downgraded to category 3)

With relation to category 3 EU stocks:

- 6 stocks were added
 - had.27.6b (downgraded from category 1)
 - her.27.6aN (split from her.27.6a7bc)
 - her.27.6aS7bc (split from her.27.6a7bc)
 - rjc.27.8c (split from rjc.27.8)
 - rjm.27.9a (upgraded to cat 3)
 - pil.27.7 (5 years available for the first time)
- 8 stocks were dropped:
 - rjc.27.8 (split to rjc.27.8c and rjc.27.8abd)
 - rjr.27.23a4 (final year 2018)
 - her.27.6a7bc (split into her.27.6aN and her.27.6aS7bc)
 - rju.27.7de (upgraded to category 2)
 - ple.27.24-32 (upgraded to category 2)
 - ank.27.78abd (upgraded to category 1)
 - hke.27.8c9a (upgraded to category 1)
 - cod.27.7a (upgraded to category 1)

As in previous years, non-EU stock pra.27.1-2 was excluded from the dataset to compute the indicator 'F/F_{MSY} outside EU waters' due to its high impact on the scale of the indicator.

2.3.2 *Mediterranean and Black Seas*

No stocks were dropped from the list compared to last year.

The following stocks have been included with a change in the area definition:

- Deep water rose shrimp formerly in GSA 6 now in GSA 5, 6 and 7
- Deep water rose shrimp formerly in GSA 9, 10 and 11 now in GSA 8, 9, 10 and 11
- Blue and red shrimp formerly in GSA 1, now in GSA 1 and 2
- Mantis shrimp formerly in GSA 17 and 18, now in GSA 17

The following stocks have been added:

- Deep water rose shrimp in GSA 1
- Blue and red shrimp in GSA 5
- Blue and red shrimp in GSA 18, 19 and 20
- Red mullet in GSA 19
- Red shrimp in GSA 18, 19 and 20
- Norway lobster in GSA 5
- Norway lobster in GSA 15 and 16
- Striped mullet in GSA 15 and 16
- Anchovy in GSA 7
- Anchovy in GSA 9
- Anchovy in GSA 16
- Cuttlefish in GSA 17
- Horned Octopus GSA 18
- Red mullet in GSA 25
- Red mullet in GSA 29
- Sardine in GSA 9
- Sardine in GSA 16
- Sardine in GSA 17 and 18
- Blackspot sea bream in GSA 1 and 3
- Axillary sea bream in GSA 25
- Sprat in GSA 29
- Whiting in GSA 29

Four stocks had available CMSY assessments: common cuttlefish in GSA 17, axillary seabream in GSA 25, horned octopus in GSA 18 and Venus clam in GSA 17 and 18. Only the first three were included in the analysis, because they were considered suitable for advice by the RFMO (GFCM); the Venus clam assessment performed by EWG 2216 was not considered suitable for advice by STECF.

2.3.3 *EU Waters indicators*

As in the last years' reports (STECF, 2021a and 2022a), an extra section was added to report results for two indicators of fisheries state for all EU Waters (joining FAO area 27 and 37): one indicator for F/F_{MSY} and one for B/B_{2003} .

3 NORTHEAST ATLANTIC AND ADJACENT SEAS (FAO REGION 27)

3.1 Number of stock assessments available to compute CFP performance indicators

The number of stock assessments with estimates of F/F_{MSY} for the years 2003-2021 for FAO region 27 are given in Figure 1. The global values as well as the breakdown by Ecoregion are provided in Table 1.

The detailed time series for each category 1 and 2 stocks is presented in Figure 2. One stock (whg.27.7a) was given a 2-year advice in 2021. As a result, no estimate of F/F_{MSY} was available for this stock in 2021. The number of stocks for which F/F_{MSY} was estimated was 81 for 2020 and 80 for 2021.

The number of stocks in category 1 and 2 for which an F/F_{MSY} estimate was available increased from 73 to 81 for the time series considered (2003-2021). The highest number of F/F_{MSY} (81) estimates was recorded for the years 2017-2020.

As in last 2 year's reports (STECF, 2021a and 2022a), cod.27.24-32 was not included in the analysis. Although it has been upgraded from category 3 to category 1 in 2020 (ICES, 2021b), the absence of F_{MSY} and $MSYB_{trigger}$ prevented its inclusion in the analysed dataset according to the protocol.

8 EU category 1-2 stocks were excluded because they are not in the agreed sampling frame (absence of stock-specific TACs) (see section 2.1.2)

- rjn.27.678abd (new category 2 – under combined skates and rays TAC)
- rjc.27.8abd (new category 2 – split from rjc.27.8 – under combined skates and rays TAC)
- tur.27.3a (new category 2 – no TAC)
- pil.27.8c9a (category 1 – no TAC)
- bss.27.4bc7ad-h (category 1 – no TAC)
- bss.27.8ab (category 1 – no TAC)
- her.27.1-24a514a (category 1 – no TAC)
- pil.27.8abd (category 1 – no TAC)

Stocks lez.27.4a6a, lez.27.6b, nep.fu.25, nep.fu.2627, nep.fu.31, ple.27.24-32, por.27.nea, rju.27.7de, pra.27.1-2 (non-EU), ghl.27.561214 (non-EU) were assessed in the framework of category 1 or 2 using Bayesian biomass dynamic models. These models provide estimates of B/B_{MSY} that were used to assess their status against CFP criteria (CFP, i.e. $F \leq F_{MSY}$ and $B \geq B_{MSY}$). Since B_{PA} is defined as a fraction of B_{MSY} or not at all, and B_{MSY} is not reported as an absolute value, these stocks are not taken into account by the SBL indicator.

There are 5 EU stocks managed with a $B_{escapment}$ strategy (san.sa.1r, san.sa.2r, san.sa.3r, san.sa.4, spr.27.3a4) for which ICES set $MSYB_{escapment}$ at B_{PA} and not at B_{MSY} .

The management of ane.27.8 is set according to the adopted plan that stipulates that a harvest control rule (HCR) with 2 biomass trigger points is used. For this stock, ICES report only B_{lim} and the 2 trigger points as SSB_{mgt} reference points.

In the case of nop.27.3a4, a probabilistic method is used to set the catches such as $C_{y+1} = C | (P[SSB < B_{lim}] = 0.05)$. B_{lim} and F_{cap} are both estimated and B_{PA} is derived such as $B_{PA} = B_{lim} \cdot \exp(\sigma \cdot 1.645)$.

Out of the 71 stocks with MSY reference points, 44 stocks have $MSYB_{trigger}$ set at B_{PA} levels, 22 stocks do not have a B_{PA} defined, 4 stocks have $B_{PA} = B_{lim} \cdot \exp(\sigma \cdot 1.645)$ and one stock is assessed using an ensemble of 3 SS3 models with $B_{PA} = 0.8 \cdot B_{MSY}$.

To keep consistency with the new ICES definition, widely distributed stocks are referred to as "Widely" in the figures and tables of this section, and not anymore as "Northeast Atlantic" as in past reports.

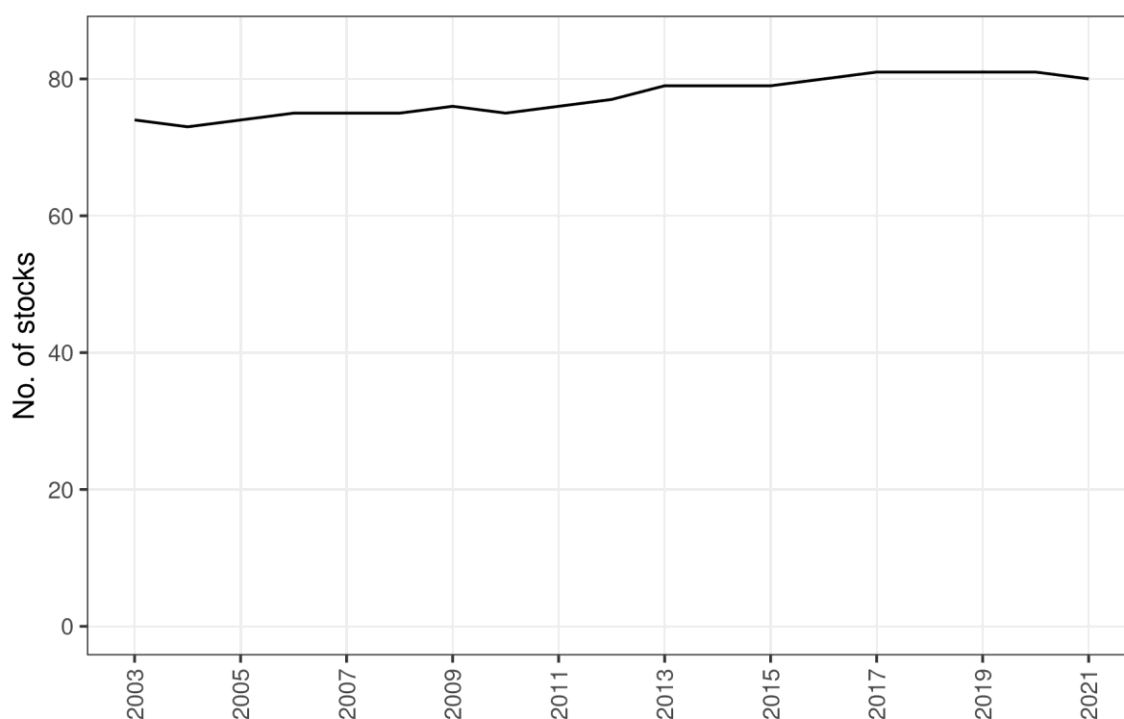


Figure 1: Number of stocks in the NE Atlantic for which estimates of F/F_{MSY} are available by year

Table 1: Number of stocks in the ICES area for which estimates of F/F_{MSY} are available by ecoregion and year

EcoRegion	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
ALL	74	73	74	75	75	75	76	75	76	77
Baltic Sea	9	9	9	9	9	9	9	9	9	9
BoBiscay & Iberia	14	14	14	14	14	14	14	14	14	14
Celtic Seas	22	21	22	23	23	23	24	23	24	25
Greater North Sea	22	22	22	22	22	22	22	22	22	22
Widely	7	7	7	7	7	7	7	7	7	7

EcoRegion	2013	2014	2015	2016	2017	2018	2019	2020	2021
ALL	79	79	79	80	81	81	81	81	80
Baltic Sea	9	9	9	9	9	9	9	9	9
BoBiscay & Iberia	14	14	14	15	15	15	15	15	15
Celtic Seas	27	27	27	27	27	27	27	27	26
Greater North Sea	22	22	22	22	23	23	23	23	23
Widely	7	7	7	7	7	7	7	7	7

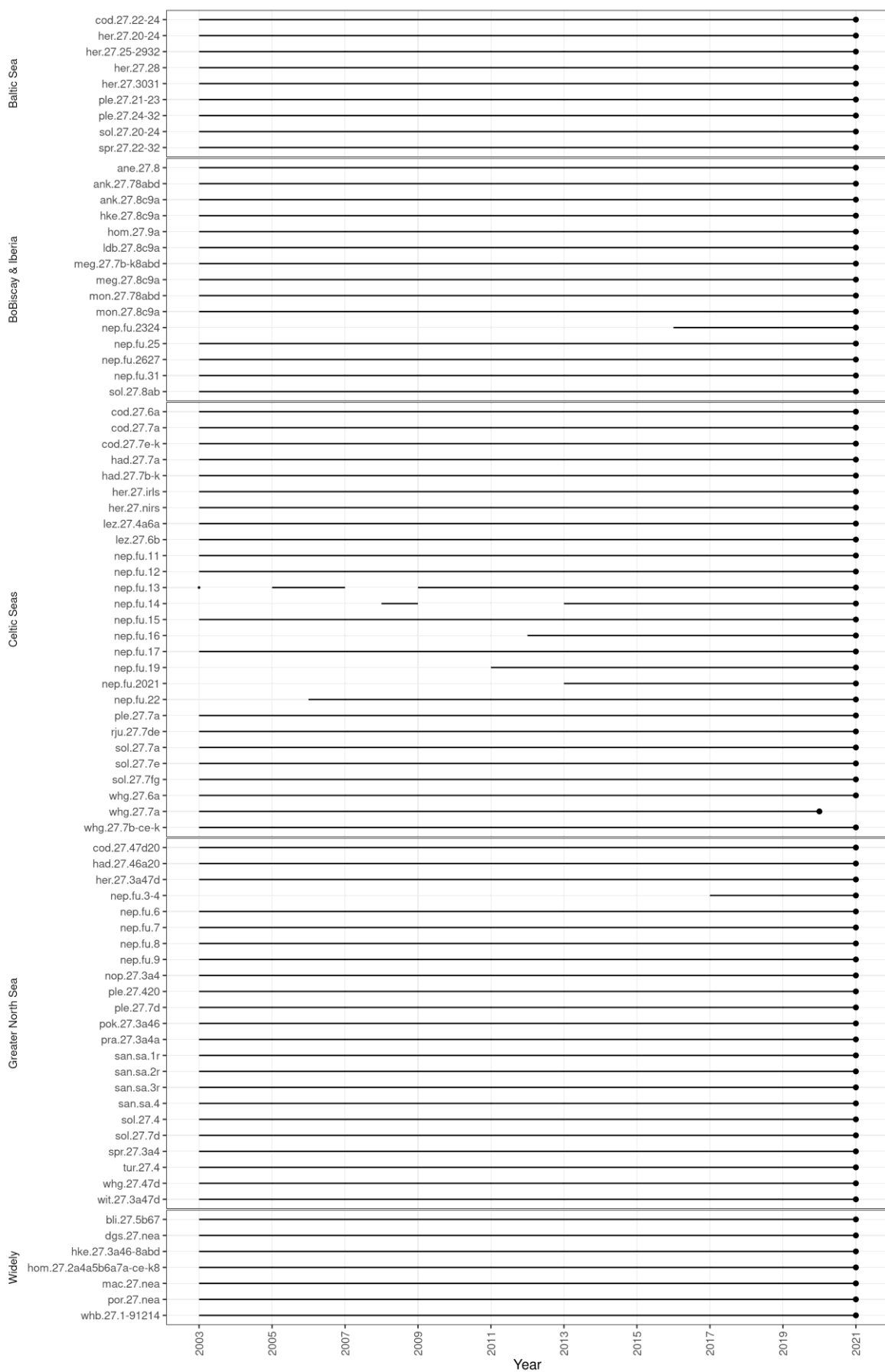


Figure 2: Time series of stock assessment results in the NE Atlantic for which estimates of F/F_{MSY} are available by year. Blank records indicate that no estimate was available for the stock in that year.

Table 2: Indicators computed for each stock

Stocks	Year	Above/Below F_{MSY}	In/Out SBL	In/Out CFP	F/F_{MSY} trends	Biomass trends	Decadal recruitment trends	Biomass data category 3 trends
ane.27.8	2021	X				X	X	
ane.27.9a	2021							X
anf.27.3a46	2021							X
ank.27.78abd	2021	X	X		X	X	X	
ank.27.8c9a	2021	X		X	X			
aru.27.6b7-1012	2020							X
bli.27.5b67	2021	X	X		X	X	X	
bll.27.22-32	2019							X
bll.27.3a47de	2021							X
boc.27.6-8	2021							X
bsf.27.nea	2021							X
bwp.27.2729-32	2021							X
bzq.27.2425	2021							X
bzq.27.2628	2021							X
cod.27.2.coastS	2021							X
cod.27.21	2021							X
cod.27.22-24	2021	X	X		X	X	X	
cod.27.47d20	2021	X	X		X	X	X	
cod.27.6a	2021	X	X		X	X	X	
cod.27.7a	2021	X	X		X	X	X	
cod.27.7e-k	2021	X	X		X	X	X	
dab.27.22-32	2019							X
dab.27.3a4	2021							X
dgs.27.nea	2021	X	X			X	X	
fle.27.2223	2021							X
fle.27.3a4	2021							X
gfb.27.nea	2021							X
gug.27.3a47d	2021							X

Stocks	Year	Above/Below F_{MSY}	In/Out SBL	In/Out CFP	F/F_{MSY} trends	Biomass trends	Decadal recruitment trends	Biomass data category 3 trends
gur.27.3-8	2020							X
had.27.46a20	2021	X	X		X	X	X	
had.27.6b	2021							X
had.27.7a	2021	X	X	X	X	X	X	
had.27.7b-k	2021	X	X		X	X	X	
her.27.20-24	2021	X	X		X	X	X	
her.27.25-2932	2021	X	X		X	X	X	
her.27.28	2021	X	X	X	X	X	X	
her.27.3031	2021	X	X		X	X	X	
her.27.3a47d	2021	X	X	X	X	X	X	
her.27.6aN	2021							X
her.27.6a57bc	2021							X
her.27.irls	2021	X	X		X	X	X	
her.27.nirs	2021	X	X		X	X	X	
hke.27.3a46-8abd	2021	X	X		X	X	X	
hke.27.8c9a	2021	X	X		X	X	X	
hom.27.2a4a5b6a7a-ce-k8	2021	X	X		X	X	X	
hom.27.3a4bc7d	2019							X
hom.27.9a	2021	X		X	X	X	X	
ldb.27.8c9a	2021	X	X		X	X	X	
lem.27.3a47d	2021							X
lez.27.4a6a	2021	X		X	X			
lez.27.6b	2021	X		X	X			
lin.27.346-91214	2020							X
mac.27.nea	2021	X	X		X	X	X	
meg.27.7b-k8abd	2021	X	X		X	X	X	
meg.27.8c9a	2021	X	X		X	X	X	
mon.27.78abd	2021	X	X		X	X	X	
mon.27.8c9a	2021	X	X	X	X	X	X	

Stocks	Year	Above/Below F_{MSY}	In/Out SBL	In/Out CFP	F/F_{MSY} trends	Biomass trends	Decadal recruitment trends	Biomass data category 3 trends
nep.fu.11	2021	X		X				
nep.fu.12	2021	X		X				
nep.fu.13	2021	X		X				
nep.fu.14	2021	X		X				
nep.fu.15	2021	X		X				
nep.fu.16	2021	X						
nep.fu.17	2021	X		X				
nep.fu.19	2021	X		X				
nep.fu.2021	2021	X		X				
nep.fu.22	2021	X		X				
nep.fu.2324	2021	X						
nep.fu.25	2021	X		X	X			
nep.fu.2627	2021	X		X	X			
nep.fu.2829	2020							X
nep.fu.3-4	2021	X						
nep.fu.30	2021							X
nep.fu.31	2021	X		X	X			
nep.fu.6	2021	X		X				
nep.fu.7	2021	X		X				
nep.fu.8	2021	X		X				
nep.fu.9	2021	X		X				
nop.27.3a4	2021	X				X	X	
pil.27.7	2021							X
ple.27.21-23	2021	X	X		X	X	X	
ple.27.24-32	2021	X		X	X			
ple.27.420	2021	X	X		X	X	X	
ple.27.7a	2021	X	X	X	X	X	X	
ple.27.7d	2021	X	X		X	X	X	
ple.27.7e	2021							X

Stocks	Year	Above/Below F_{MSY}	In/Out SBL	In/Out CFP	F/F_{MSY} trends	Biomass trends	Decadal recruitment trends	Biomass data category 3 trends
ple.27.7fg	2021							X
ple.27.7h-k	2021							X
pok.27.3a46	2021	X	X		X	X	X	
por.27.nea	2021	X		X	X			
pra.27.3a4a	2021	X		X	X		X	
raj.27.1012	2019							X
rjc.27.3a47d	2020							X
rjc.27.6	2021							X
rjc.27.7afg	2021							X
rjc.27.8c	2020							X
rjc.27.9a	2021							X
rje.27.7fg	2021							X
rjh.27.4c7d	2019							X
rjh.27.9a	2021							X
rjm.27.3a47d	2020							X
rjm.27.67bj	2021							X
rjm.27.7ae-h	2021							X
rjm.27.8	2020							X
rjm.27.9a	2021							X
rjn.27.3a4	2020							X
rjn.27.8c	2020							X
rjn.27.9a	2020							X
rju.27.7de	2021	X		X	X			
rng.27.3a	2021							X
san.sa.1r	2021	X				X	X	
san.sa.2r	2021	X				X	X	
san.sa.3r	2021	X				X	X	
san.sa.4	2021	X				X	X	
sbr.27.10	2021							X

Stocks	Year	Above/Below F_{MSY}	In/Out SBL	In/Out CFP	F/F_{MSY} trends	Biomass trends	Decadal recruitment trends	Biomass data category 3 trends
sbr.27.9	2021							X
sdv.27.nea	2020							X
sho.27.67	2020							X
sho.27.89a	2020							X
sol.27.20-24	2021	X	X		X	X	X	
sol.27.4	2021	X	X		X	X	X	
sol.27.7a	2021	X	X		X	X	X	
sol.27.7d	2021	X	X		X	X	X	
sol.27.7e	2021	X	X	X	X	X	X	
sol.27.7fg	2021	X	X		X	X	X	
sol.27.8ab	2021	X	X		X	X	X	
sol.27.8c9a	2020							X
spr.27.22-32	2021	X	X		X	X	X	
spr.27.3a4	2021	X				X	X	
spr.27.7de	2021							X
syc.27.3a47d	2020							X
syc.27.67a-ce-j	2020							X
syc.27.8abd	2020							X
syc.27.8c9a	2020							X
syt.27.67	2019							X
tur.27.22-32	2020							X
tur.27.4	2021	X	X	X	X	X	X	
usk.27.3a45b6a7-912b	2020							X
whb.27.1-91214	2021	X	X		X	X	X	
whg.27.3a	2021							X
whg.27.47d	2021	X	X		X	X	X	
whg.27.6a	2021	X	X		X	X	X	
whg.27.7a	2020	X	X		X	X	X	
whg.27.7b-ce-k	2021	X	X		X	X	X	

Stocks	Year	Above/Below F_{MSY}	In/Out SBL	In/Out CFP	F/F_{MSY} trends	Biomass trends	Decadal recruitment trends	Biomass data category 3 trends
wit.27.3a47d	2021	X	X		X	X	X	
TOTAL		81	47	31	57	55	56	64

3.2 Indicators of management performance

The first set of indicators (Figure 3 to Figure 8 and Table 3 to Table 8) represent the number of stocks with relation to specific thresholds. Until last year's report (STECF, 2022a), the representation of these indicators was made in pairs, with one indicator showing the number of stocks above/outside the relevant thresholds, followed by another showing the number of stocks below/inside. A new presentation of the same indicators was agreed by STECF (2022d) where the mirror indicators will be presented stacked on top of each other. The second set of indicators (Figure 9 to Figure 17 and Table 9 to Table 16) depicts time trends of indicators computed using a statistical model. Most indicators have a global and a regional depiction (indicators 1-8 and 10). Some sensitivity analyses were performed for the two F/F_{MSY} indicators and presented in Annex 5.

3.2.1 Number of stocks by year where fishing mortality is above/below F_{MSY}

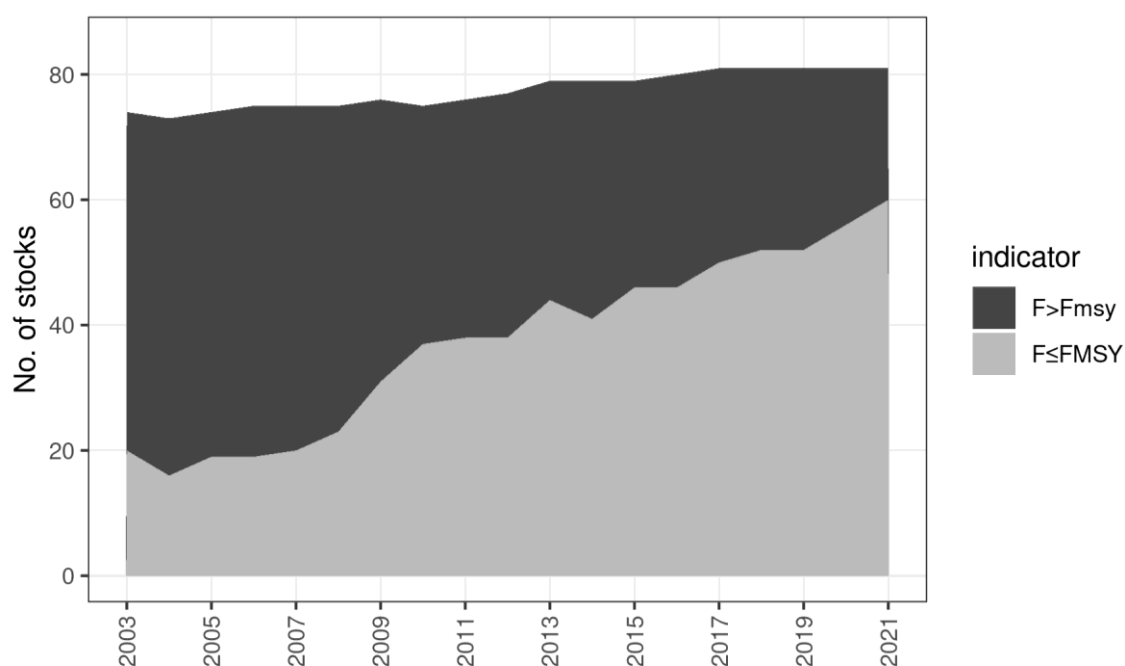


Figure 3: Number of stocks by year for which fishing mortality (F) was above/below F_{MSY} (NEAI1-2)

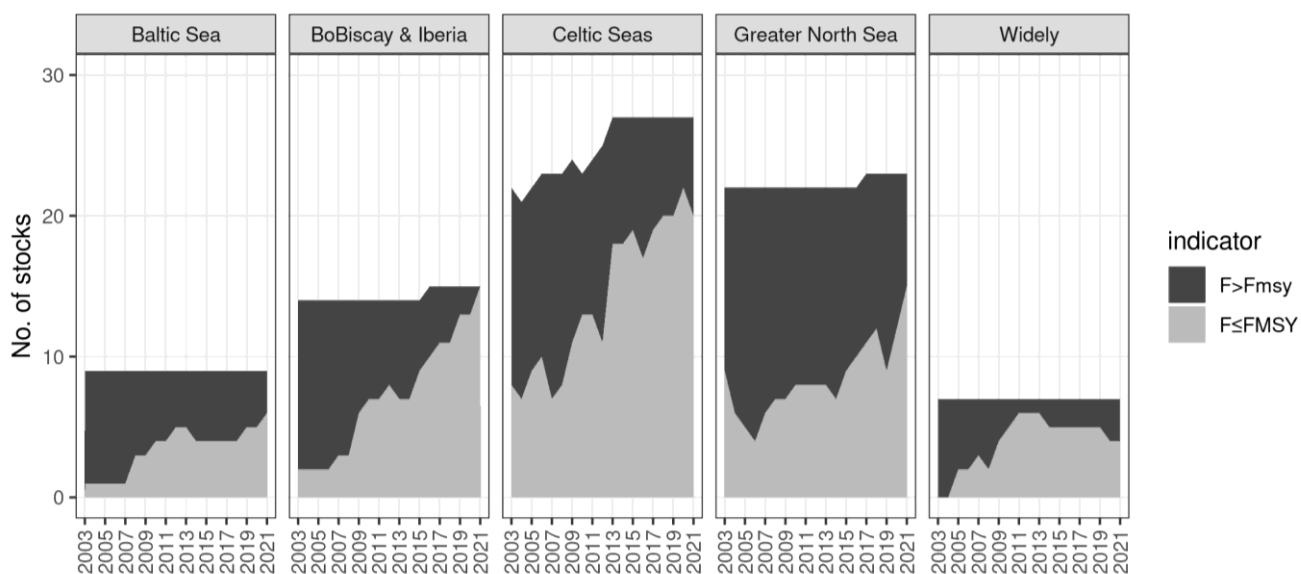


Figure 4: Number of stocks by ecoregion for which fishing mortality (F) was above/below F_{MSY} (NEAI1-2b)

Table 3: Number of stocks by ecoregion for which fishing mortality (F) exceeded F_{MSY} (NEAI1)

EcoRegion	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
ALL	54	57	55	56	55	52	45	38	38	39
Baltic Sea	8	8	8	8	8	6	6	5	5	4
BoBiscay & Iberia	12	12	12	12	11	11	8	7	7	6
Celtic Seas	14	14	13	13	16	15	13	10	11	14
Greater North Sea	13	16	17	18	16	15	15	14	14	14
Widely	7	7	5	5	4	5	3	2	1	1

EcoRegion	2013	2014	2015	2016	2017	2018	2019	2020	2021
ALL	35	38	33	34	31	29	29	25	21
Baltic Sea	4	5	5	5	5	5	4	4	3
BoBiscay & Iberia	7	7	5	5	4	4	2	2	0
Celtic Seas	9	9	8	10	8	7	7	5	7
Greater North Sea	14	15	13	12	12	11	14	11	8
Widely	1	2	2	2	2	2	2	3	3

Table 4: Number of stocks by ecoregion for which fishing mortality (F) did not exceed F_{MSY} (NEAI2)

EcoRegion	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
ALL	20	16	19	19	20	23	31	37	38	38
Baltic Sea	1	1	1	1	1	3	3	4	4	5
BoBiscay & Iberia	2	2	2	2	3	3	6	7	7	8
Celtic Seas	8	7	9	10	7	8	11	13	13	11
Greater North Sea	9	6	5	4	6	7	7	8	8	8
Widely	0	0	2	2	3	2	4	5	6	6

EcoRegion	2013	2014	2015	2016	2017	2018	2019	2020	2021
ALL	44	41	46	46	50	52	52	56	60
Baltic Sea	5	4	4	4	4	4	5	5	6
BoBiscay & Iberia	7	7	9	10	11	11	13	13	15
Celtic Seas	18	18	19	17	19	20	20	22	20
Greater North Sea	8	7	9	10	11	12	9	12	15
Widely	6	5	5	5	5	5	5	4	4

3.2.2 Number of stocks outside or inside safe biological limits

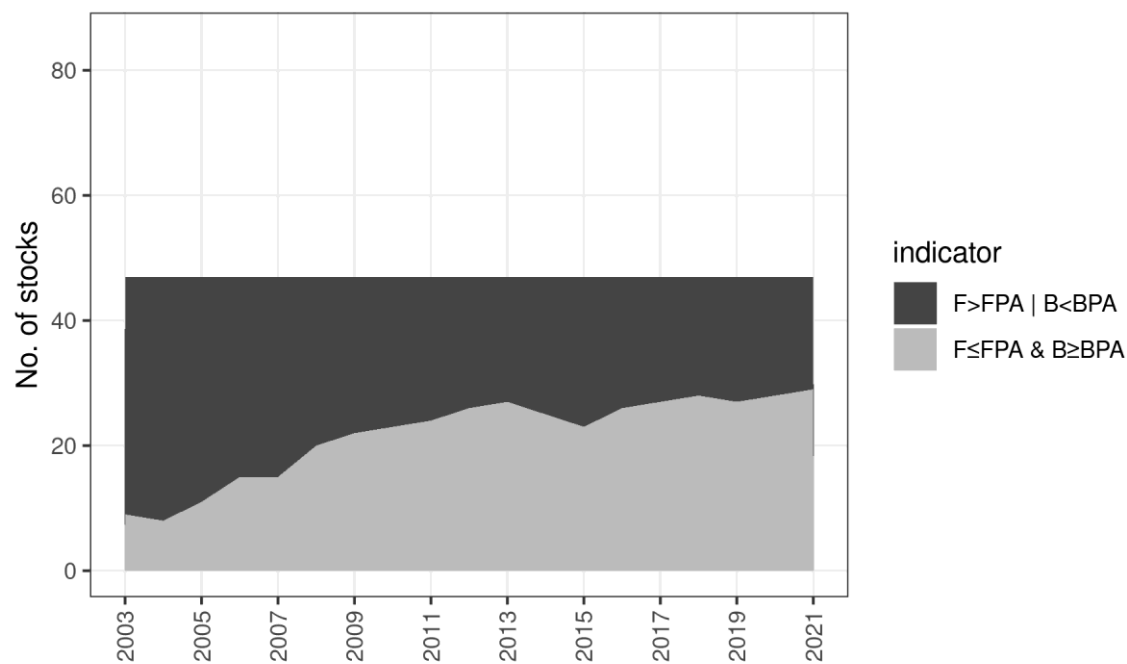


Figure 5: Number of stocks outside/inside safe biological limits by year (NEAI3-4)

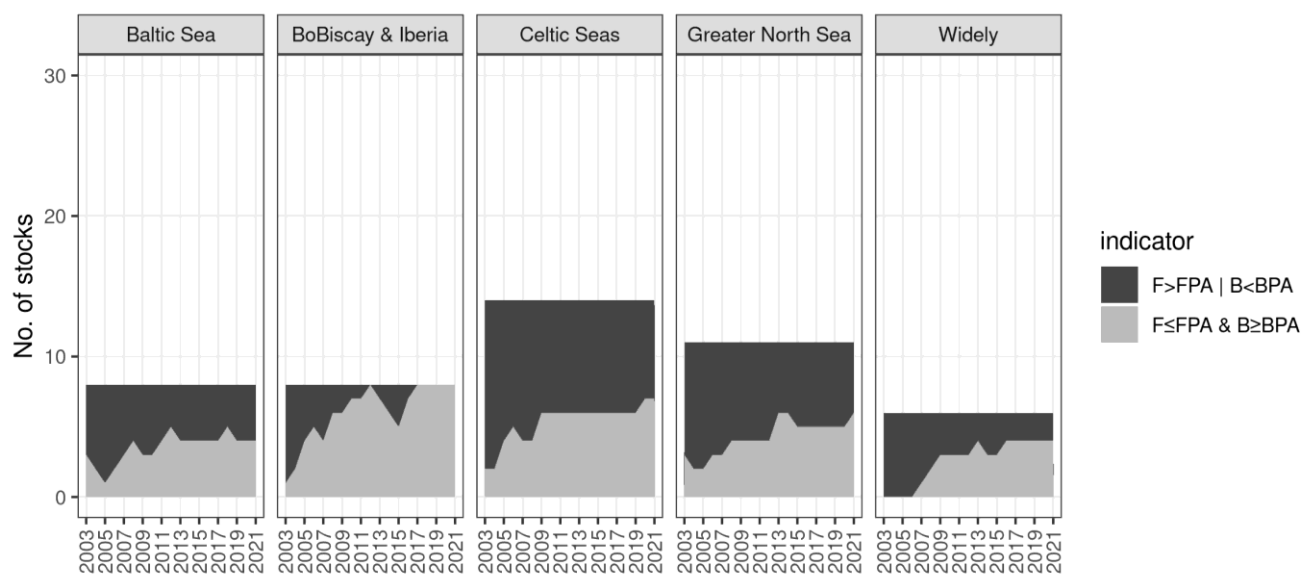


Figure 6: Number of stocks outside/inside safe biological limits by ecoregion (NEAI3-4b)

Table 5: Number of stocks outside safe biological limits by ecoregion (NEAI3)

EcoRegion	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
ALL	38	39	36	32	32	27	25	24	23	21
Baltic Sea	5	6	7	6	5	4	5	5	4	3
BoBiscay & Iberia	7	6	4	3	4	2	2	1	1	0
Celtic Seas	12	12	10	9	10	10	8	8	8	8
Greater North Sea	8	9	9	8	8	7	7	7	7	7
Widely	6	6	6	6	5	4	3	3	3	3

EcoRegion	2013	2014	2015	2016	2017	2018	2019	2020	2021
ALL	20	22	24	21	20	19	20	19	18
Baltic Sea	4	4	4	4	4	3	4	4	4
BoBiscay & Iberia	1	2	3	1	0	0	0	0	0
Celtic Seas	8	8	8	8	8	8	8	7	7
Greater North Sea	5	5	6	6	6	6	6	6	5
Widely	2	3	3	2	2	2	2	2	2

Table 6: Number of stocks inside safe biological limits by ecoregion (NEAI4)

EcoRegion	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
ALL	9	8	11	15	15	20	22	23	24	26
Baltic Sea	3	2	1	2	3	4	3	3	4	5
BoBiscay & Iberia	1	2	4	5	4	6	6	7	7	8
Celtic Seas	2	2	4	5	4	4	6	6	6	6
Greater North Sea	3	2	2	3	3	4	4	4	4	4
Widely	0	0	0	0	1	2	3	3	3	3

EcoRegion	2013	2014	2015	2016	2017	2018	2019	2020	2021
ALL	27	25	23	26	27	28	27	28	29
Baltic Sea	4	4	4	4	4	5	4	4	4
BoBiscay & Iberia	7	6	5	7	8	8	8	8	8
Celtic Seas	6	6	6	6	6	6	6	7	7
Greater North Sea	6	6	5	5	5	5	5	5	6
Widely	4	3	3	4	4	4	4	4	4

3.2.3 Number of stocks with $F > F_{MSY}$ or $SSB < B_{MSY}$ and number of stocks with $F \leq F_{MSY}$ and $SSB \geq B_{MSY}$

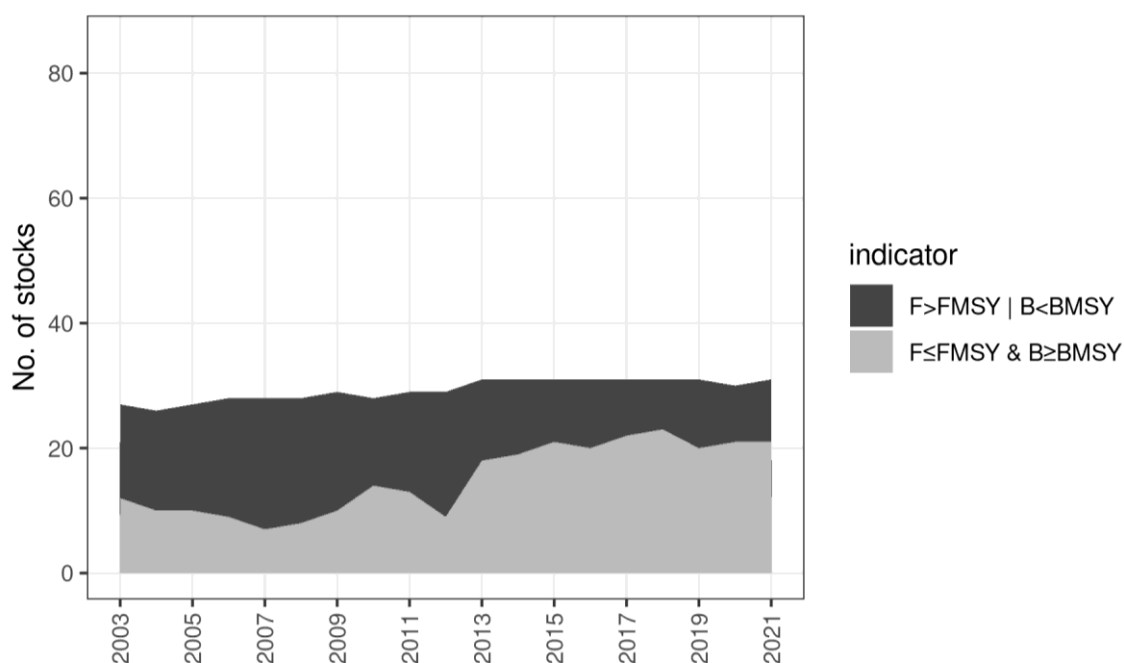


Figure 7: Number of stocks with $F > F_{MSY}$ or $SSB < B_{MSY}$ and number of stocks with $F \leq F_{MSY}$ and $SSB \geq B_{MSY}$ (NEAI5-6)

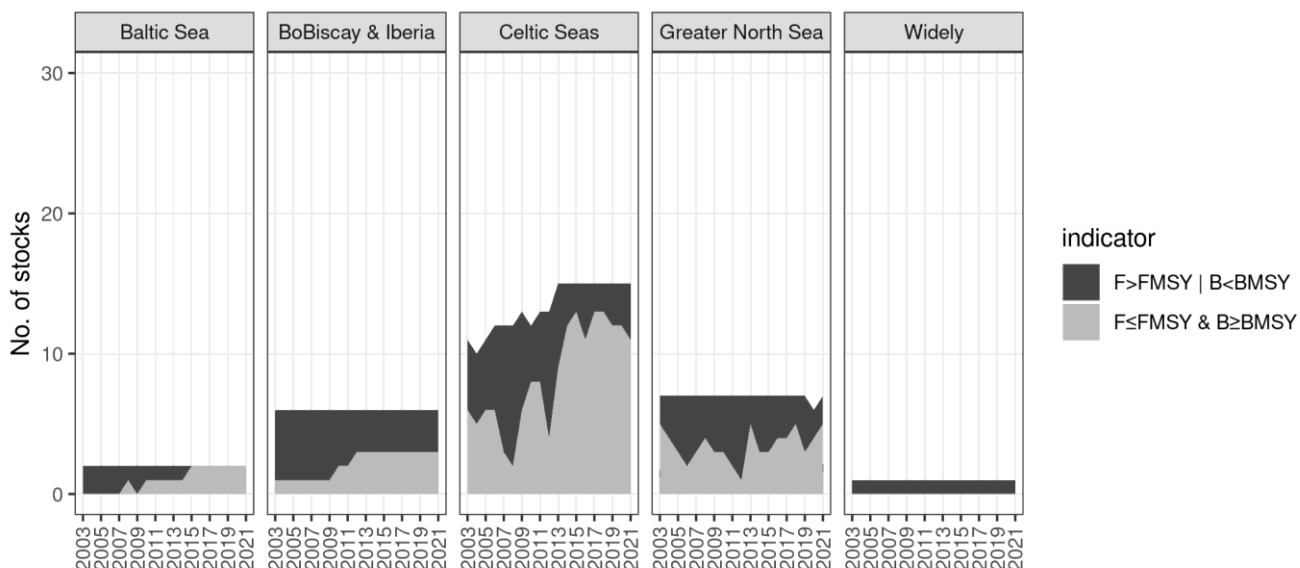


Figure 8: Number of stocks with $F > F_{MSY}$ or $SSB < B_{MSY}$ and number of stocks with $F \leq F_{MSY}$ and $SSB \geq B_{MSY}$ by ecoregion (NEAI5-6b)

Table 7: Number of stocks with $F > F_{MSY}$ or $SSB < B_{MSY}$ by ecoregion (NEAI5)

EcoRegion	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
ALL	15	16	17	19	21	20	19	14	16	20
Baltic Sea	2	2	2	2	2	1	2	1	1	1
BoBiscay & Iberia	5	5	5	5	5	5	5	4	4	3
Celtic Seas	5	5	5	6	9	10	7	4	5	9
Greater North Sea	2	3	4	5	4	3	4	4	5	6
Widely	1	1	1	1	1	1	1	1	1	1

EcoRegion	2013	2014	2015	2016	2017	2018	2019	2020	2021
ALL	13	12	10	11	9	8	11	9	10
Baltic Sea	1	1	0	0	0	0	0	0	0
BoBiscay & Iberia	3	3	3	3	3	3	3	3	3
Celtic Seas	6	3	2	4	2	2	3	3	4
Greater North Sea	2	4	4	3	3	2	4	2	2
Widely	1	1	1	1	1	1	1	1	1

Table 8: Number of stocks with $F \leq F_{MSY}$ and $SSB \geq B_{MSY}$ by ecoregion (NEAI6)

EcoRegion	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
ALL	12	10	10	9	7	8	10	14	13	9
Baltic Sea	0	0	0	0	0	1	0	1	1	1
BoBiscay & Iberia	1	1	1	1	1	1	1	2	2	3
Celtic Seas	6	5	6	6	3	2	6	8	8	4
Greater North Sea	5	4	3	2	3	4	3	3	2	1
Widely	0	0	0	0	0	0	0	0	0	0

EcoRegion	2013	2014	2015	2016	2017	2018	2019	2020	2021
ALL	18	19	21	20	22	23	20	21	21
Baltic Sea	1	1	2	2	2	2	2	2	2
BoBiscay & Iberia	3	3	3	3	3	3	3	3	3
Celtic Seas	9	12	13	11	13	13	12	12	11
Greater North Sea	5	3	3	4	4	5	3	4	5
Widely	0	0	0	0	0	0	0	0	0

3.2.4 Trend in F/F_{MSY}

The ratio F/F_{MSY} has decreased over the years 2003-2021 from 1.68 to 0.76 (Figure 9 and Table 9). The ratio's median estimate went <1 from 2012 and was significantly <1 in 2020 and 2021. In Annex 5 is presented a sensitivity analysis that highlights the impact of the inclusion of biomass dynamic models on the scale of the indicator.

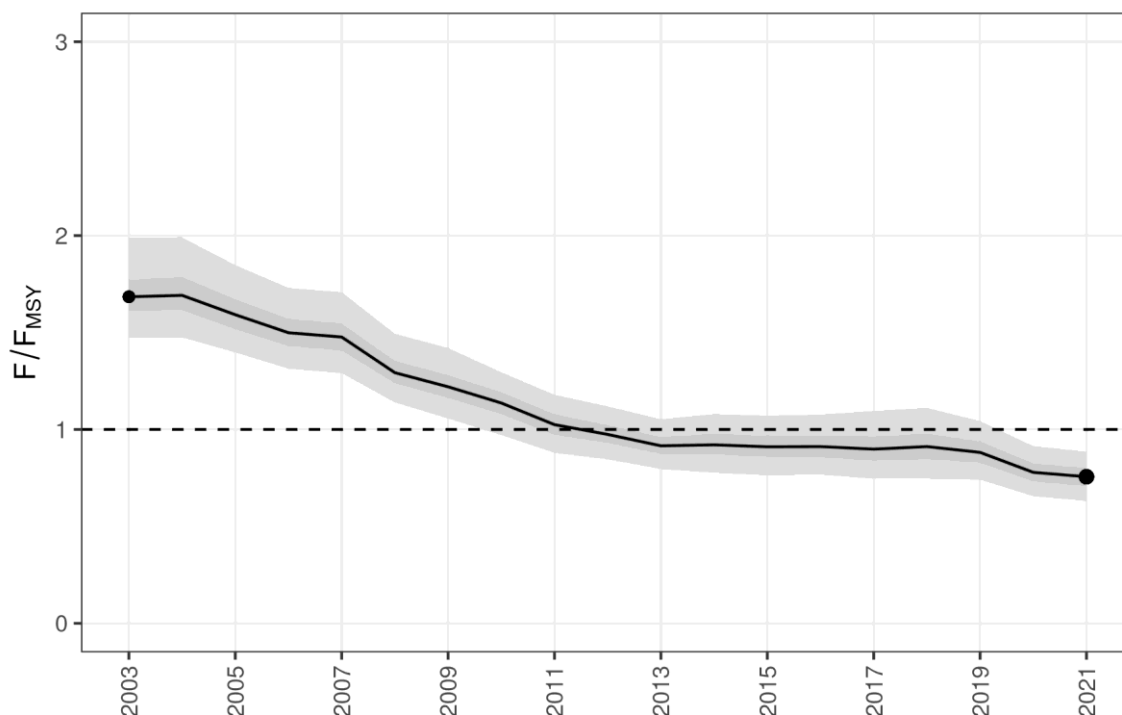


Figure 9: Trend in F/F_{MSY} (based on 57 stocks). Dark grey area shows the 50% confidence interval whereas the light grey shows the 95% confidence interval (NEAI7)

Table 9: Percentiles for F/F_{MSY} by year (NEAI7)

Percentiles	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
2.5%	1.47	1.47	1.40	1.31	1.29	1.14	1.06	0.97	0.88	0.85
25%	1.61	1.62	1.52	1.43	1.41	1.24	1.16	1.08	0.97	0.93
50%	1.68	1.69	1.59	1.50	1.48	1.29	1.22	1.14	1.02	0.97
75%	1.77	1.79	1.67	1.57	1.55	1.35	1.28	1.19	1.08	1.02
97.5%	1.99	1.99	1.85	1.73	1.71	1.49	1.42	1.30	1.18	1.12

Percentiles	2013	2014	2015	2016	2017	2018	2019	2020	2021
2.5%	0.79	0.78	0.76	0.77	0.74	0.75	0.74	0.65	0.63
25%	0.88	0.87	0.86	0.86	0.84	0.85	0.83	0.73	0.71
50%	0.92	0.92	0.91	0.91	0.90	0.91	0.88	0.78	0.76
75%	0.96	0.98	0.97	0.97	0.96	0.98	0.94	0.82	0.80
97.5%	1.05	1.08	1.07	1.08	1.10	1.11	1.04	0.91	0.89

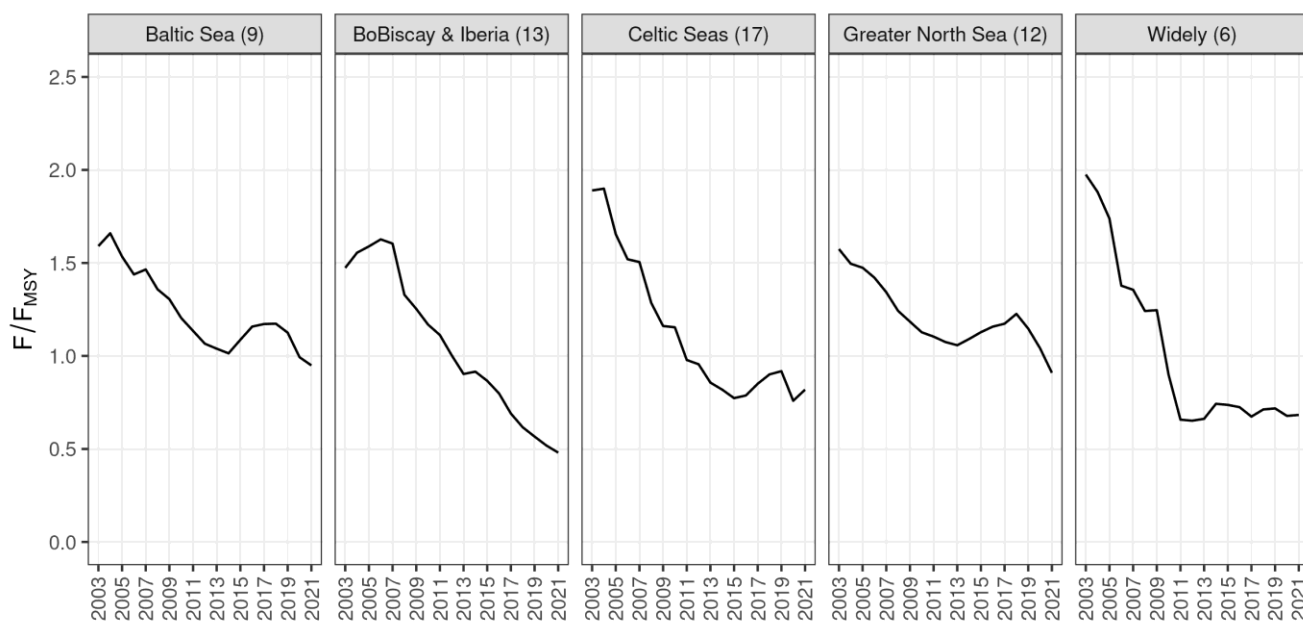


Figure 10: Trend in F/F_{MSY} by ecoregion. The number of stocks in each ecoregion are shown between parentheses (NEAI7b)

Table 10: Trend in F/F_{MSY} by ecoregion (NEAI7b)

EcoRegion	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Baltic Sea	1.59	1.66	1.53	1.44	1.46	1.36	1.31	1.20	1.13	1.07
BoBiscay & Iberia	1.47	1.56	1.59	1.63	1.60	1.33	1.25	1.17	1.11	1.00
Celtic Seas	1.89	1.90	1.65	1.52	1.50	1.29	1.16	1.15	0.98	0.96
Greater North Sea	1.57	1.50	1.47	1.42	1.34	1.24	1.18	1.13	1.10	1.07
Widely	1.98	1.88	1.74	1.38	1.36	1.24	1.25	0.90	0.66	0.65

EcoRegion	2013	2014	2015	2016	2017	2018	2019	2020	2021
Baltic Sea	1.04	1.01	1.09	1.16	1.17	1.17	1.13	0.99	0.95
BoBiscay & Iberia	0.90	0.92	0.87	0.80	0.69	0.62	0.57	0.52	0.48
Celtic Seas	0.86	0.82	0.77	0.79	0.85	0.90	0.92	0.76	0.82
Greater North Sea	1.06	1.09	1.13	1.16	1.17	1.23	1.15	1.04	0.91
Widely	0.66	0.74	0.74	0.72	0.67	0.71	0.72	0.68	0.68

3.2.5 Trend in F/F_{MSY} for stocks outside EU waters

The model used in section 3.2.4 was also used with data derived from stocks assessed by ICES and spanning across areas that fall primarily outside EU waters in FAO region 27 (Figure 11 and Table 11). The analysis was based on 16 stocks for which individual F/F_{MSY} trajectories are presented in Figure 12. Throughout the time series, the ratio did not exhibit any increasing or decreasing trend. The median of the ratio was >1 throughout the time series. A sensitivity analysis including pra.27.1-2 and showing how this stock impact the scale of this indicator is presented in Annex 5. The confidence interval of the indicator overlapped with 1 in some years. An increase of the indicator occurred from 2017 to 2020 followed by a decrease in 2021.

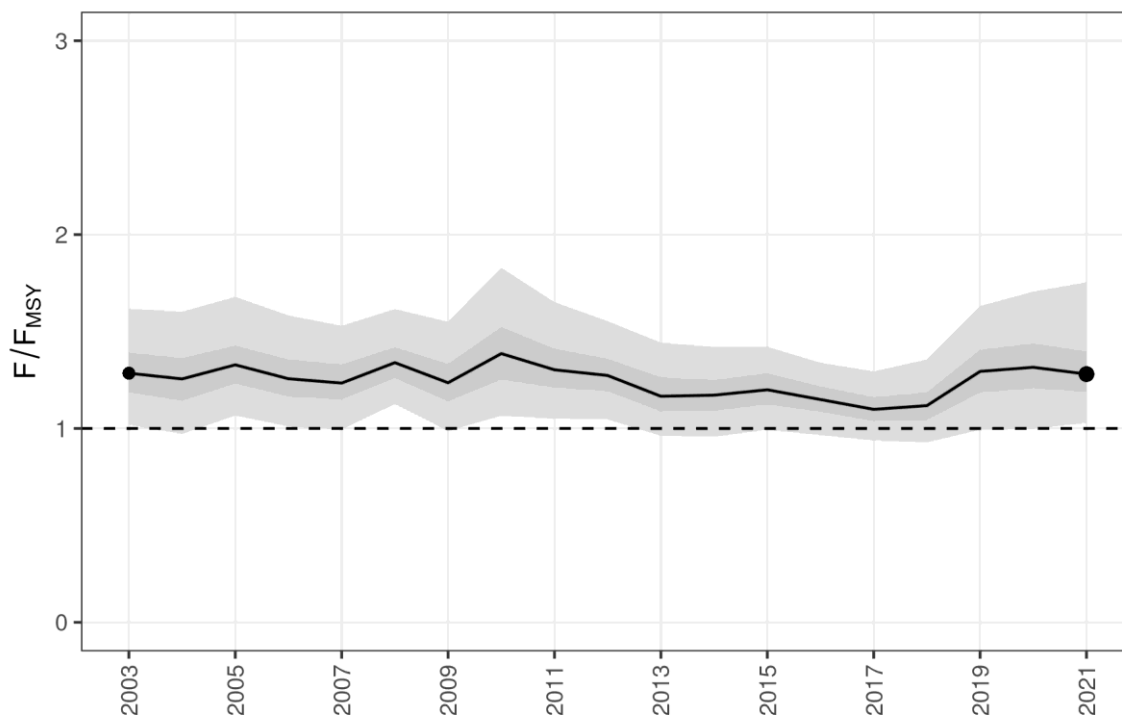


Figure 11: Trend in F/F_{MSY} for stocks outside EU waters (based on 16 stocks). Dark grey zone shows the 50% confidence interval whereas the light grey zone shows the 95% confidence interval (NEAI7out)

Table 11: Percentiles for F/F_{MSY} for stocks outside EU waters (NEAI7out)

Percentiles	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
2.5%	1.02	0.97	1.07	1.01	1.00	1.13	0.99	1.07	1.05	1.05
25%	1.19	1.14	1.23	1.17	1.15	1.26	1.14	1.25	1.21	1.19
50%	1.28	1.26	1.33	1.26	1.23	1.34	1.24	1.39	1.30	1.27
75%	1.39	1.36	1.43	1.35	1.33	1.42	1.33	1.52	1.41	1.36
97.5%	1.62	1.60	1.68	1.58	1.53	1.62	1.55	1.83	1.65	1.55

Percentiles	2013	2014	2015	2016	2017	2018	2019	2020	2021
2.5%	0.96	0.96	0.99	0.97	0.94	0.93	0.99	1.00	1.03
25%	1.09	1.09	1.13	1.09	1.04	1.05	1.19	1.21	1.19
50%	1.17	1.17	1.20	1.15	1.10	1.12	1.29	1.32	1.28
75%	1.26	1.25	1.28	1.22	1.16	1.18	1.40	1.44	1.40
97.5%	1.44	1.42	1.42	1.34	1.29	1.36	1.63	1.71	1.75

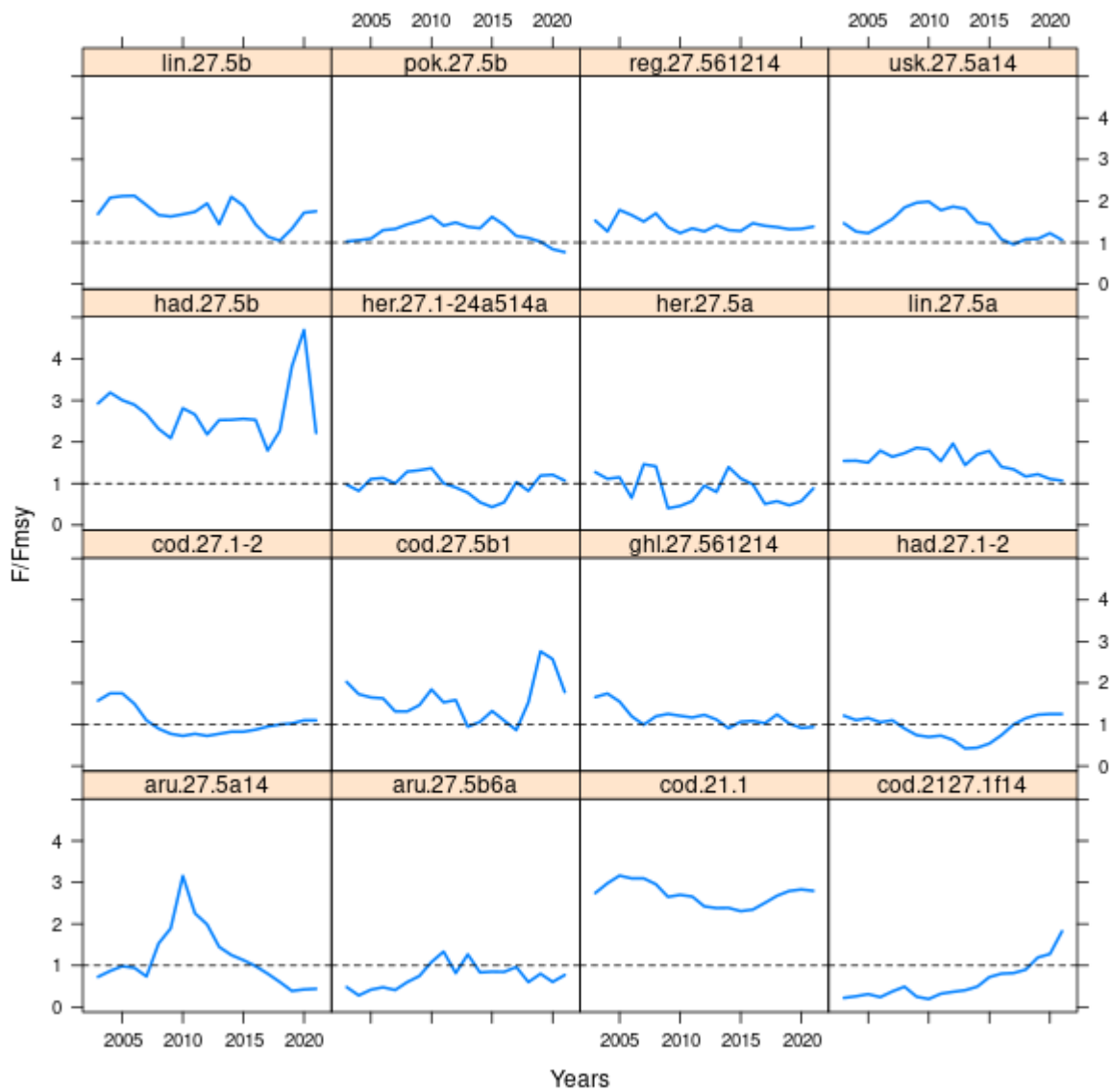


Figure 12: Trend in F/F_{MSY} of single stocks from outside EU waters. The dashed line is set at 1 (i.e. where $F=F_{MSY}$)

3.2.6 Trend in SSB (relative to SSB in 2003)

The ratio B/B_{2003} increased over the years 2003-2021 to reach 1.39 (Figure 13 and Table 12). Over the years 2003-2007, the indicator has decreased to 0.84 (minimum of the time series). The following increasing trend reached its peak in 2011 (1.18). Over the following years, after two decreasing years, the index followed an increasing trend to reach its final maximum. The ratio's confidence interval overlaps with 1 throughout the time series.

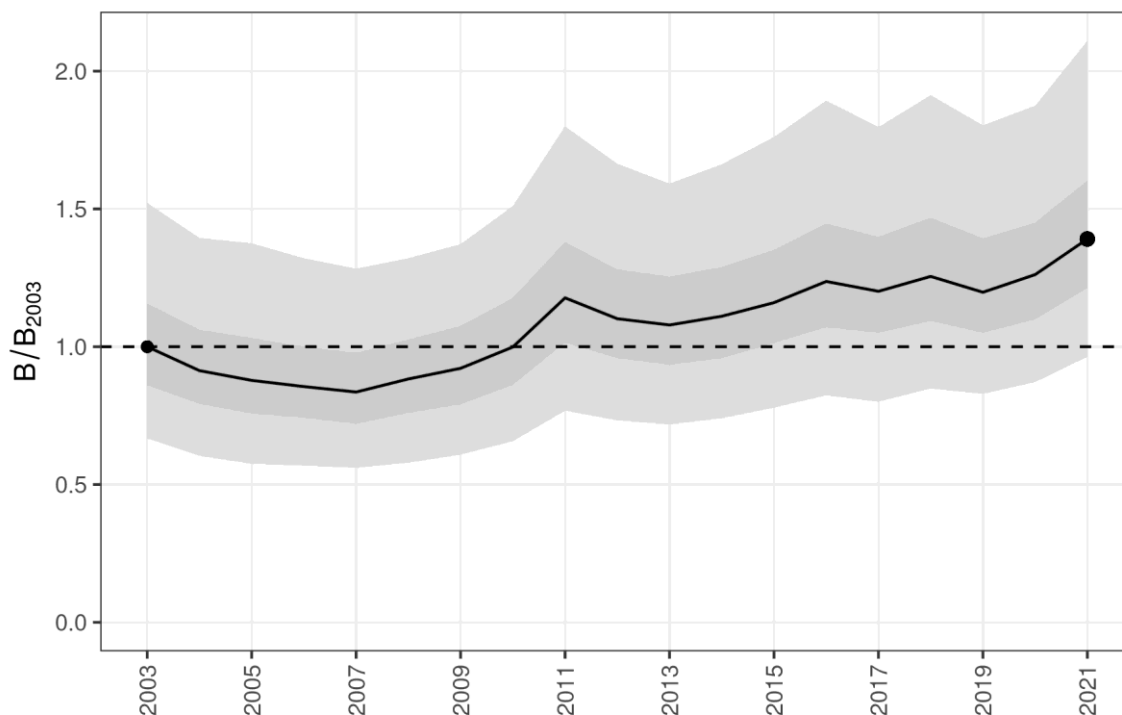


Figure 13: Trend in SSB relative to 2003 (based on 55 stocks). Dark grey zone shows the 50% confidence interval whereas the light grey zone shows the 95% confidence interval (NEAI8)

Table 12: Percentiles for SSB relative to 2003

Percentiles	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
2.5%	0.67	0.60	0.57	0.57	0.56	0.58	0.61	0.66	0.77	0.73
25%	0.86	0.79	0.76	0.74	0.72	0.76	0.79	0.86	1.02	0.96
50%	1.00	0.91	0.88	0.86	0.84	0.88	0.92	1.00	1.18	1.10
75%	1.16	1.06	1.03	1.00	0.98	1.03	1.07	1.18	1.38	1.28
97.5%	1.52	1.40	1.38	1.32	1.28	1.32	1.37	1.51	1.80	1.66

Percentiles	2013	2014	2015	2016	2017	2018	2019	2020	2021
2.5%	0.72	0.74	0.78	0.82	0.80	0.85	0.83	0.87	0.96
25%	0.94	0.96	1.01	1.07	1.05	1.09	1.05	1.10	1.21
50%	1.08	1.11	1.16	1.24	1.20	1.26	1.20	1.26	1.39
75%	1.25	1.29	1.35	1.45	1.40	1.47	1.39	1.45	1.60
97.5%	1.59	1.66	1.76	1.89	1.80	1.91	1.80	1.87	2.11

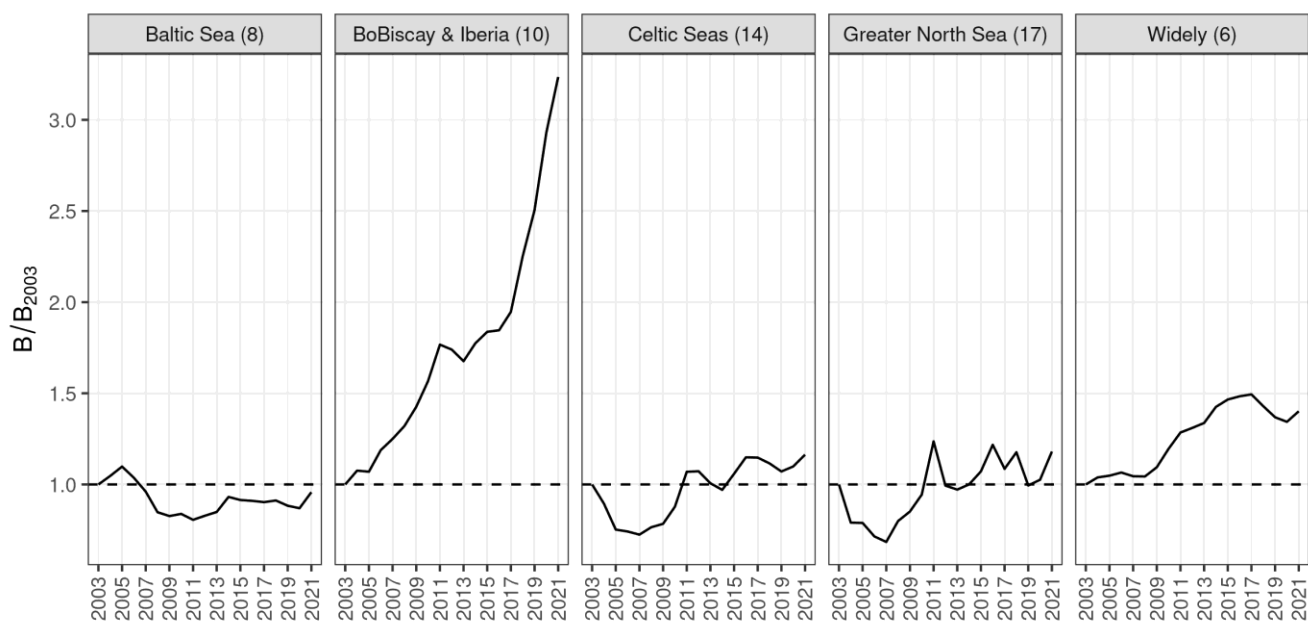


Figure 14: Trend in SSB relative to 2003 by ecoregion. The number of stocks in each ecoregion are shown between parentheses (NEAI8b)

Table 13: SSB relative to 2003 by ecoregion

EcoRegion	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Baltic Sea	1.00	1.05	1.10	1.04	0.96	0.85	0.83	0.84	0.81	0.83
BoBiscay & Iberia	1.00	1.08	1.07	1.19	1.25	1.32	1.43	1.57	1.77	1.74
Celtic Seas	1.00	0.89	0.75	0.74	0.72	0.77	0.78	0.88	1.07	1.07
Greater North Sea	1.00	0.79	0.79	0.71	0.68	0.80	0.85	0.94	1.24	0.99
Widely	1.00	1.04	1.05	1.07	1.05	1.04	1.09	1.20	1.28	1.31

EcoRegion	2013	2014	2015	2016	2017	2018	2019	2020	2021
Baltic Sea	0.85	0.93	0.91	0.91	0.90	0.91	0.88	0.87	0.96
BoBiscay & Iberia	1.68	1.77	1.84	1.85	1.95	2.25	2.51	2.93	3.24
Celtic Seas	1.01	0.97	1.06	1.15	1.15	1.12	1.07	1.10	1.16
Greater North Sea	0.97	1.00	1.07	1.22	1.09	1.18	0.99	1.03	1.18
Widely	1.34	1.43	1.47	1.48	1.49	1.43	1.37	1.34	1.40

3.2.7 Trend in biomass relative to biomass in 2003 for data-limited stocks

The biomass/abundance for category 3 stocks inside EU waters (Figure 15 and Table 14) have increased over the years 2003-2015 to reach its maximum of the series (1.8). Over the years 2015-2021 the ratio decreased to 1.46. The lower bound of the confidence interval was <1 throughout the time series.

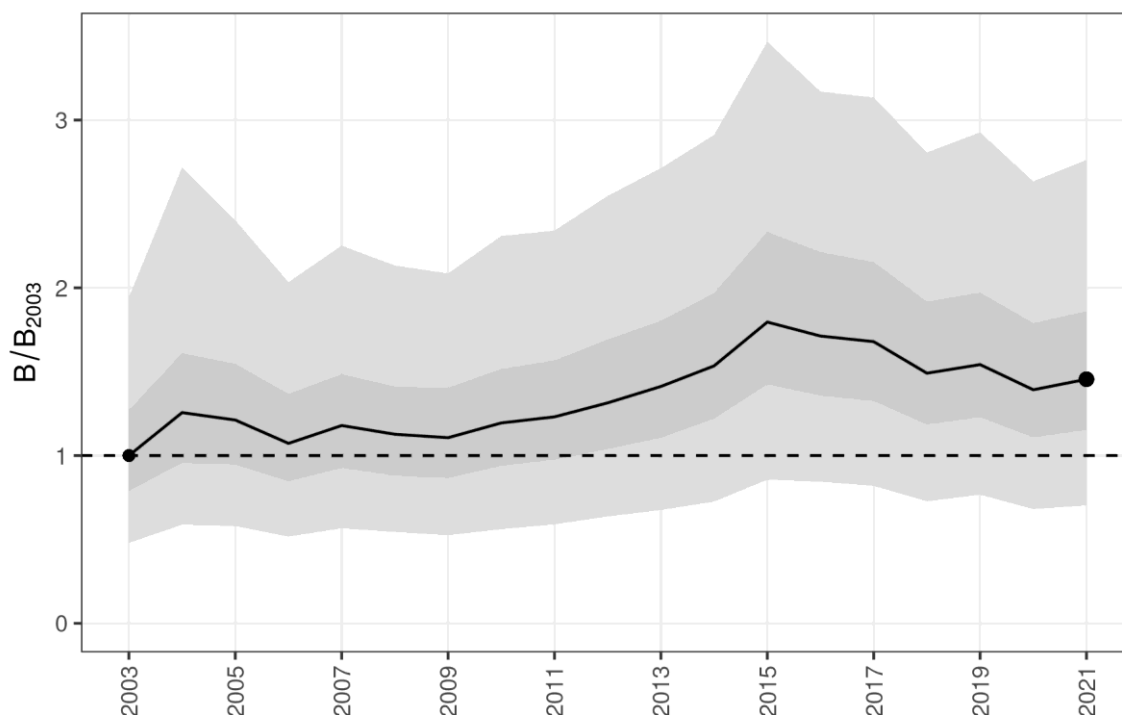


Figure 15: Trend in biomass or abundance indices relative to 2003 for data limited stocks (ICES category 3; based on 64 stocks). Dark grey zone shows the 50% confidence interval whereas the light grey zone shows the 95% confidence interval (NEAI12)

Table 14: Percentiles for biomass or abundance indices relative to 2003 for ICES category 3 stocks

Percentiles	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
2.5%	0.48	0.59	0.58	0.52	0.57	0.54	0.52	0.56	0.59	0.64
25%	0.79	0.96	0.95	0.85	0.93	0.88	0.87	0.94	0.98	1.04
50%	1.00	1.26	1.21	1.07	1.18	1.13	1.11	1.19	1.23	1.31
75%	1.27	1.61	1.55	1.37	1.48	1.41	1.40	1.51	1.57	1.69
97.5%	1.94	2.72	2.40	2.03	2.25	2.13	2.09	2.31	2.34	2.55

Percentiles	2013	2014	2015	2016	2017	2018	2019	2020	2021
2.5%	0.67	0.72	0.86	0.84	0.82	0.73	0.77	0.68	0.70
25%	1.11	1.22	1.43	1.36	1.33	1.19	1.23	1.11	1.16
50%	1.41	1.53	1.80	1.71	1.68	1.49	1.54	1.39	1.46
75%	1.80	1.97	2.33	2.21	2.15	1.92	1.97	1.79	1.86
97.5%	2.71	2.91	3.47	3.17	3.13	2.81	2.93	2.63	2.76

3.2.8 Trend in recruitment relatively to recruitment 2003

The estimated average decadal recruitment for category 1 and 2 stocks (Figure 16 and Table 15) followed a decreasing trend from 2003 to 2012 where it reached the minimum of the time series (0.85). From 2012 to the end of the time series the decadal recruitment increased linearly and reached the maximum of the time series in 2021 (1.21). The confidence interval did not overlap with 1 only in years 2012 (the estimate was below 1) and in 2020 and 2021 (the estimates were above 1). It should be noted that several category 1 and 2 stocks were omitted due to them being assessed using biomass dynamic models. This trend might reflect an increase in stock production although the characteristic of the indicator, a decadal ratio, makes it difficult to interpret.

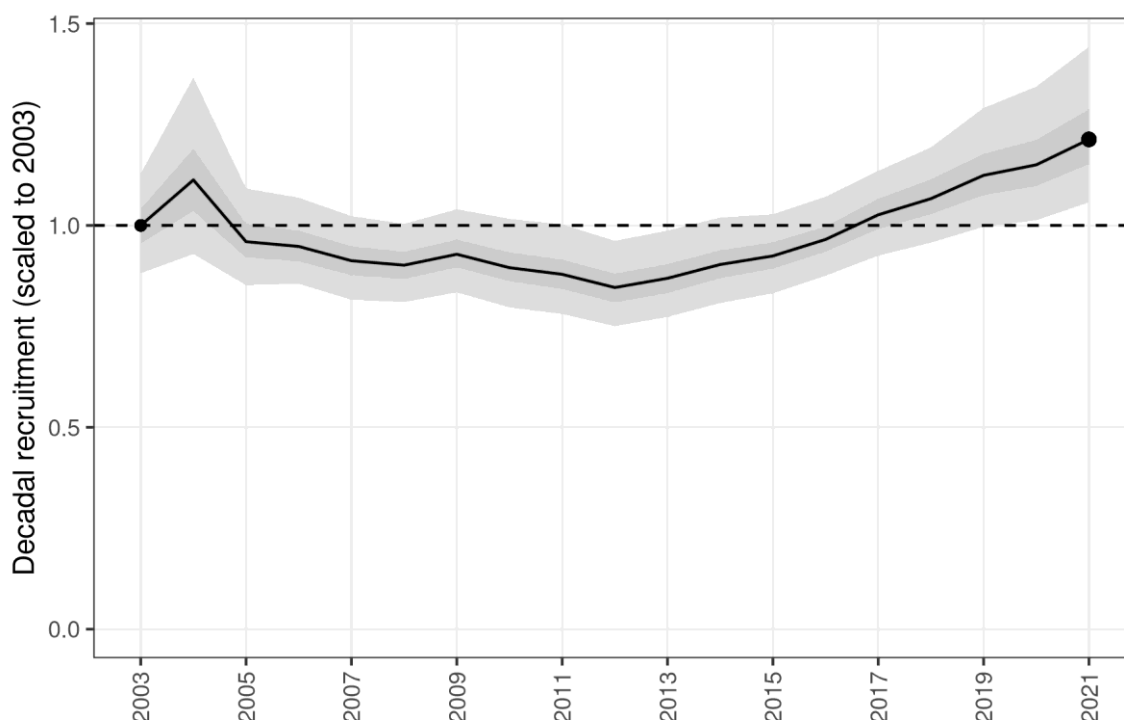


Figure 16: Trend in decadal recruitment scaled to 2003 (based on 56 stocks). Dark grey zone shows the 50% confidence interval whereas the light grey zone shows the 95% confidence interval (NEAI10)

Table 15: Percentiles for decadal recruitment scaled to 2003

Percentiles	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
2.5%	0.88	0.93	0.85	0.86	0.82	0.81	0.83	0.80	0.78	0.75
25%	0.96	1.04	0.92	0.91	0.88	0.87	0.90	0.86	0.84	0.81
50%	1.00	1.11	0.96	0.95	0.91	0.90	0.93	0.90	0.88	0.85
75%	1.04	1.19	1.00	0.99	0.95	0.93	0.96	0.93	0.91	0.88
97.5%	1.13	1.37	1.09	1.07	1.02	1.00	1.04	1.02	1.00	0.96

Percentiles	2013	2014	2015	2016	2017	2018	2019	2020	2021
2.5%	0.77	0.81	0.83	0.88	0.92	0.96	1.00	1.01	1.06
25%	0.83	0.87	0.89	0.94	0.99	1.03	1.08	1.10	1.15
50%	0.87	0.90	0.92	0.97	1.03	1.07	1.12	1.15	1.21
75%	0.90	0.94	0.96	1.00	1.07	1.11	1.18	1.21	1.29
97.5%	0.99	1.02	1.03	1.07	1.14	1.19	1.29	1.34	1.44

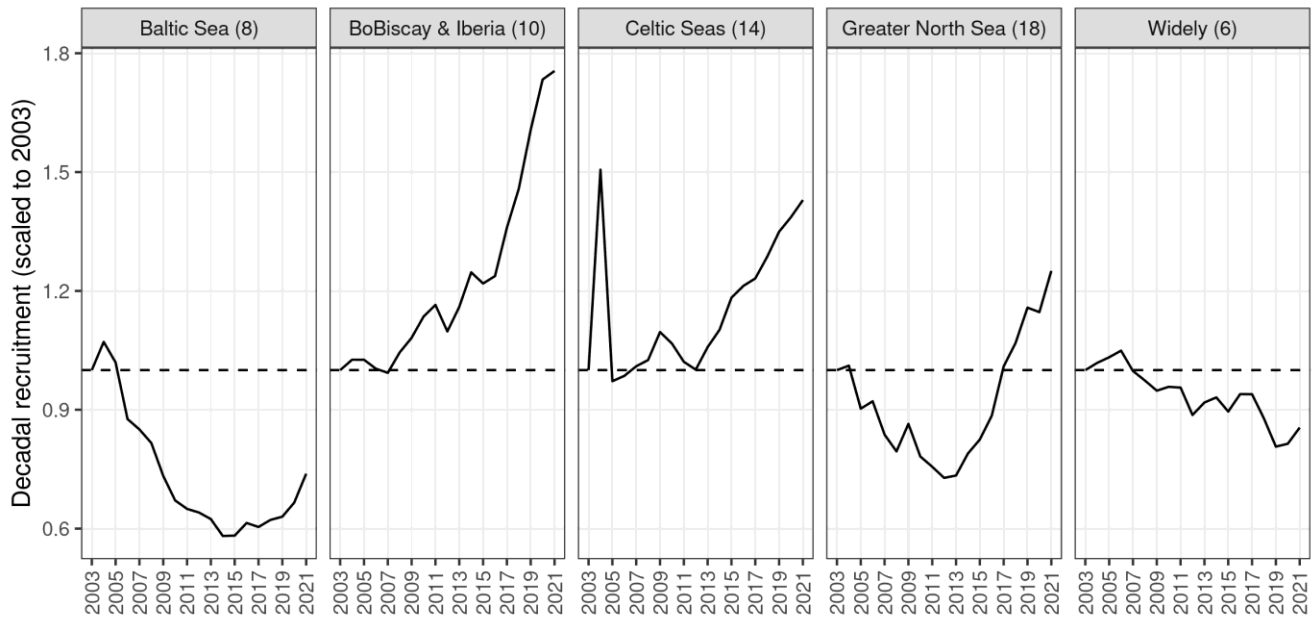


Figure 17: Trend in decadal recruitment scaled to 2003 by ecoregion. The number of stocks in each ecoregion are shown between brackets (NEAI10b)

Table 16: Decadal recruitment scaled to 2003 by ecoregion

EcoRegion	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Baltic Sea	1.00	1.07	1.02	0.88	0.85	0.82	0.73	0.67	0.65	0.64
BoBiscay & Iberia	1.00	1.03	1.03	1.00	0.99	1.04	1.08	1.14	1.16	1.10
Celtic Seas	1.00	1.51	0.97	0.99	1.01	1.03	1.10	1.07	1.02	1.00
Greater North Sea	1.00	1.01	0.90	0.92	0.84	0.79	0.86	0.78	0.76	0.73
Widely	1.00	1.02	1.03	1.05	1.00	0.97	0.95	0.96	0.96	0.89

EcoRegion	2013	2014	2015	2016	2017	2018	2019	2020	2021
Baltic Sea	0.62	0.58	0.58	0.61	0.60	0.62	0.63	0.67	0.74
BoBiscay & Iberia	1.16	1.25	1.22	1.24	1.36	1.46	1.61	1.73	1.76
Celtic Seas	1.06	1.10	1.18	1.21	1.23	1.29	1.35	1.39	1.43
Greater North Sea	0.73	0.79	0.82	0.88	1.01	1.07	1.16	1.15	1.25
Widely	0.92	0.93	0.90	0.94	0.94	0.88	0.81	0.81	0.85

3.3 Indicators of advice coverage

The indicator of advice coverage provides the number of stocks for which the reference points F_{MSY} , F_{PA} , $MSYB_{trigger}$, and B_{PA} are available (Table 17). It also provides the number of TACs that are set by the European Commission. This figure has increased this year with the addition of “por.27.nea” and “rju.27.7de”, i.e. 158. The number of stocks having reference points have increased for all the reference points.

Table 17: Coverage of TACs by scientific advice (ICES category 1 and 2)

	No of stocks	No of TACs	No of TACs based on stock assessment	Fraction of TACs based on Stock Assessments
F_{MSY}	81	158	91	0.57
$MSYB_{trigger}$	38	158	27	0.17
F_{PA}	48	158	74	0.47
B_{PA}	63	158	84	0.53

4 MEDITERRANEAN AND BLACK SEA

During the period 2003-2010 the number of stock assessments available in the 2022-analysis increased from 39 to 58 compared to the 2021-analysis (STECF 2022a) where the available stocks increased from 20 to 34 over the same period. The improvement in availability is due to the quantitative information now being available publically from GFCM. The number of available stock assessment outputs was stable from 2009 to 2019 at 58, decreasing to 54 in 2020 and 31 in 2021 (Figure 18 and Figure 19).

The variability in the number of stocks makes the interpretation of the deterministic indicators misleading. With such differences in the number of stocks assessed in the early period, the trends in the indicators are confounded with the number of stocks available for their computation. Consequently, in previous reports, only the model-based indicators for trends in F/F_{MSY} and SSB were shown. This year, B_{MSY} reference points were available for 16 Mediterranean stocks (Table 26). Hence it was decided to estimate for the first time the indicators 'number of stocks above/below F_{MSY} ' and 'number of stocks with $F > F_{MSY}$ or $SSB < B_{MSY}$ ' and 'number of stocks with $F \leq F_{MSY}$ and $SSB \geq B_{MSY}$ ', noting that it is in the period 2009-2020, when the number of available stocks is stable, that the indicator is more reliable.

The modelled bootstrap indicators provided some estimates of the variance associated with the analysis, but still assume that the entire stock population is sampled. Therefore, the indicator values presented (Figure 20 to Figure 23, and Table 19 to Table 22) are unlikely to be robust. Furthermore, the relative weighting / contributions to the mean estimate differs between the F and SSB indicators since large stocks contribute significantly more to the estimates in the latter indicator. For these reasons the results should be interpreted with caution.

Figure 18 indicates by year the number of stocks in the Mediterranean and Black Seas for which estimates of indicators are available. In 2021, the number of stock assessments available is due to the following reasons:

- STECF advice based on fully analytical assessments in the western Mediterranean was provided for 15 out of 20 stocks (STECF 2022b).
- STECF advice based on fully analytical assessments in the central and eastern Mediterranean was provided for 13 out of 16 stocks (STECF, 2022c).
- Since 2018 Black Sea stock assessments are carried out by the GFCM Black Sea Working Group. It upgraded the whiting assessment to an analytical status and although as previously, stock advice for red mullet and sprat was based on the exploitation rate equivalent, F -based reference points were provided so that four stocks are now included for the region and a regional indicator can be estimated according to the protocol for the first time.
- GFCM assessments performed in 2022 during WGSASP and WGSAD were not published by the time this report was written so that data were based on 2022 advice (2021 assessments). GFCM now publishes star files for all stocks (<https://www.fao.org/gfcm/data/star/en/>) so that data were available for an additional 24 stocks compared to last year.

Due to the reduced number of stock assessments available for 2021, the indicators are plotted as a time series up to 2020 only and 2021 is depicted as a separate point in Figure 18.

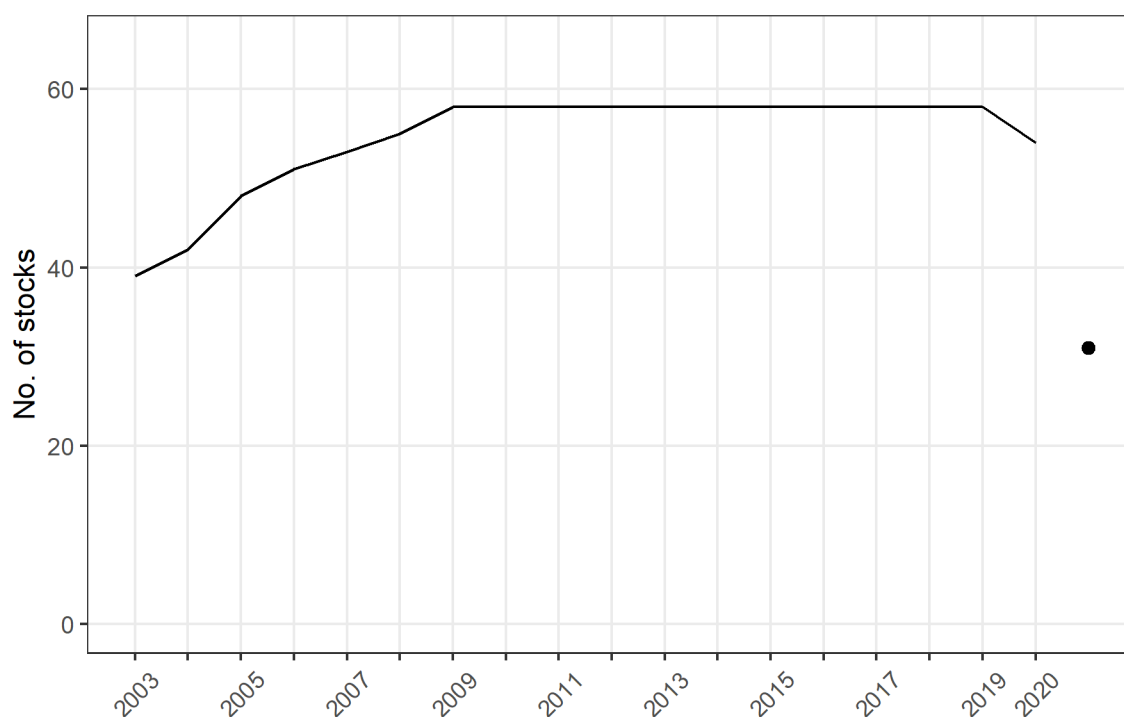


Figure 18: Number of stock assessments available in the Mediterranean and Black Sea. The totals include stocks in GSAs 1, 3, 5-20, 22, 25 and 29.

An available assessment for hake in GSA 1 and 3 from GFCM has not been included as the STECF assessment for hake in GSA 1, 5, 6 and 7 post-dates it. Therefore, no hake assessment is included for GSA 3 despite it being part of the sampling frame.

Sardine in GSA 7 was assessed using a two-stage assessment model which provides only harvest rates rather than F estimates, therefore the results are used only for the SSB indicator.

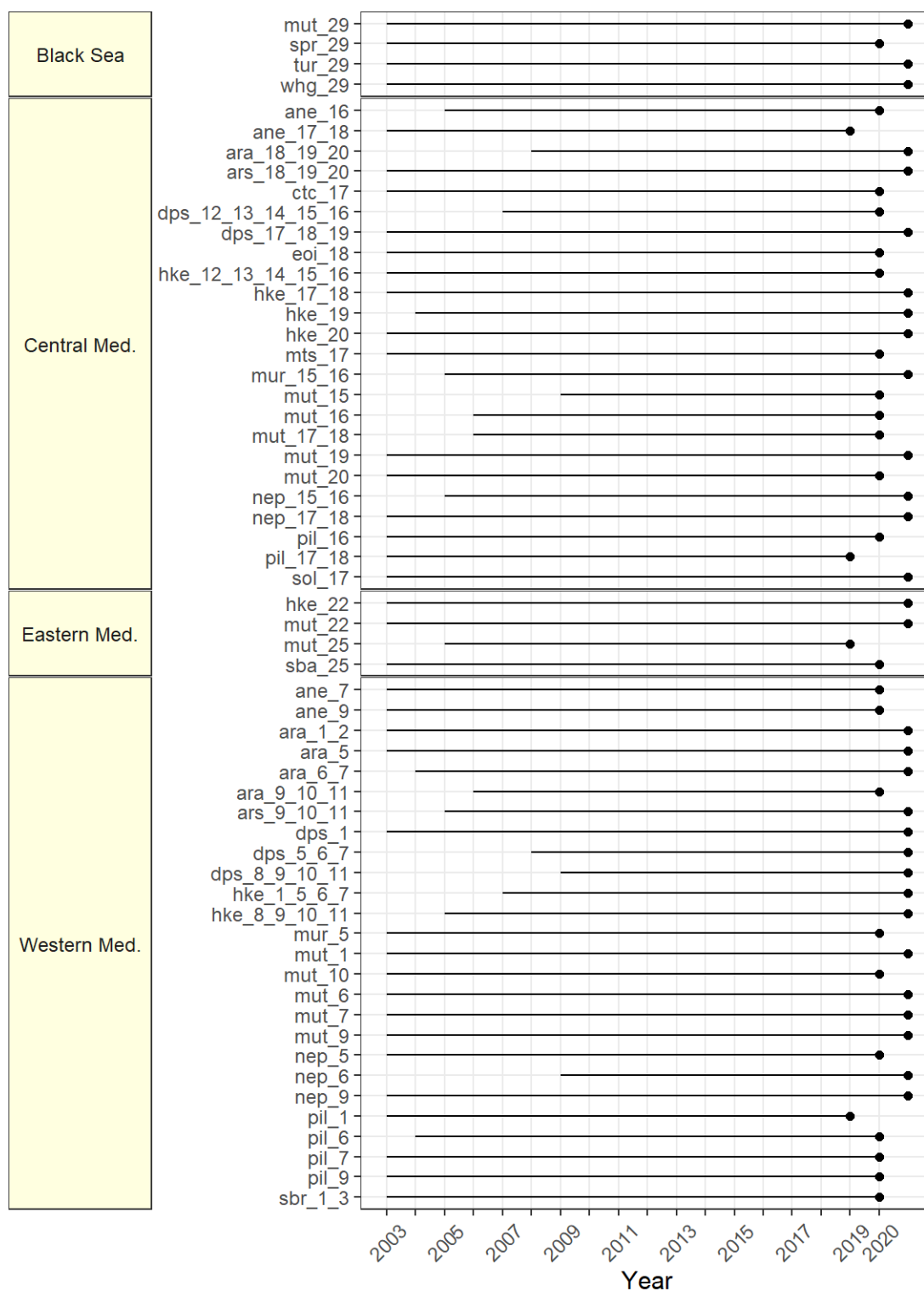


Figure 19: Time-series of stock assessments available from both STECF and GFCM for computation of model based CFP monitoring indicators for the Mediterranean and Black Seas.

Table 18: Stocks used in the 2023 CFP monitoring analysis.

EcoRegion	Final Data Year	Stock	Description	Updated	New Stock	Source
Black Sea	2021	MUT_29	Red mullet in GSA 29	2022	Yes	GFCM
Black Sea	2020	SPR_29	European sprat in GSA 29	2022	Yes	GFCM
Black Sea	2021	TUR_29	Turbot in GSA 29	2022	No	GFCM
Black Sea	2021	WHG_29	Whiting in GSA 29	2022	Yes	GFCM
Central Med.	2020	ANE_16	European anchovy in GSA 16	2022	Yes	GFCM
Central Med.	2019	ANE_17_18	European anchovy in GSA 17, 18	2021	No	GFCM
Central Med.	2021	ARA_18_19_20	Blue and red shrimp in GSA 18, 19, 20	2022	Yes	STECF
Central Med.	2021	ARS_18_19_20	Giant red shrimp in GSA 18, 19, 20	2022	Yes	STECF
Central Med.	2020	CTC_17	Common cuttlefish in GSA 17	2022	Yes	GFCM
Central Med.	2020	DPS_12_13_14_15_16	Deep-water rose shrimp in GSA 12, 13, 14, 15, 16	2022	No	GFCM
Central Med.	2021	DPS_17_18_19	Deep-water rose shrimp in GSA 17, 18, 19	2022	No	STECF
Central Med.	2020	EOI_18	Horned octopus in GSA 18	2022	Yes	GFCM
Central Med.	2020	HKE_12_13_14_15_16	European hake in GSA 12, 13, 14, 15, 16	2022	No	GFCM
Central Med.	2021	HKE_17_18	European hake in GSA 17, 18	2022	No	STECF
Central Med.	2021	HKE_19	European hake in GSA 19	2022	No	STECF
Central Med.	2020	MTS_17	Spottail mantis squillid in GSA 17	2022	GSA change	GFCM
Central Med.	2021	MUR_15_16	Striped Red Mullet (Surmullet) in GSA 15, 16	2022	Yes	STECF
Central Med.	2020	MUT_15	Red mullet in GSA 15	2022	No	GFCM
Central Med.	2020	MUT_16	Red mullet in GSA 16	2022	No	GFCM
Central Med.	2020	MUT_17_18_EWG21_15	Red mullet in GSA 17, 18, EWG21, 15	2021	No	STECF
Central Med.	2021	MUT_19	Red mullet in GSA 19	2022	Yes	STECF
Central Med.	2020	MUT_20	Red mullet in GSA 20	2022	No	GFCM
Central Med.	2021	NEP_15_16	Norway lobster in GSA 15, 16	2022	Yes	STECF
Central Med.	2021	NEP_17_18	Norway lobster in GSA 17, 18	2022	No	STECF
Central Med.	2020	PIL_16	European pilchard (=Sardine) in GSA 16	2022	Yes	GFCM
Central Med.	2019	PIL_17_18	European pilchard (=Sardine) in GSA 17, 18	2021	Yes	GFCM
Central Med.	2021	SOL_17	Common sole in GSA 17	2022	No	STECF
Eastern Med.	2021	HKE_20	European hake in GSA 20	2022	No	STECF
Eastern Med.	2021	HKE_22	European hake in GSA 22	2022	No	STECF
Eastern Med.	2021	MUT_22	Red mullet in GSA 22	2022	No	STECF
Eastern Med.	2019	MUT_25	Red mullet in GSA 25	2022	Yes	GFCM
Eastern Med.	2020	SBA_25	Axillary seabream in GSA 25	2022	Yes	GFCM

Western Med.	2020	ANE_7	European anchovy in GSA 7	2022	Yes	GFCM
Western Med.	2020	ANE_9	European anchovy in GSA 9	2022	Yes	GFCM
Western Med.	2021	ARA_1_2	Blue and red shrimp in GSA 1, 2	2022	GSA change	STECF
Western Med.	2021	ARA_5	Blue and red shrimp in GSA 5	2022	Yes	STECF
Western Med.	2021	ARA_6_7	Blue and red shrimp in GSA 6, 7	2022	No	STECF
Western Med.	2020	ARA_9_10_11	Blue and red shrimp in GSA 9, 10, 11	2022	No	GFCM
Western Med.	2021	ARS_9_10_11	Giant red shrimp in GSA 9, 10, 11	2022	No	STECF
Western Med.	2021	DPS_1	Deep-water rose shrimp in GSA 1	2022	Yes	STECF
Western Med.	2021	DPS_5_6_7	Deep-water rose shrimp in GSA 5, 6, 7	2022	GSA change	STECF
Western Med.	2021	DPS_8_9_10_11	Deep-water rose shrimp in GSA 8, 9, 10, 11	2022	GSA change	STECF
Western Med.	2021	HKE_1_5_6_7	European hake in GSA 1, 5, 6, 7	2022	No	STECF
Western Med.	2021	HKE_8_9_10_11	European hake in GSA 8, 9, 10, 11	2022	No	STECF
Western Med.	2020	MUR_5	Striped Red Mullet (Surmullet) in GSA 5	2022	No	GFCM
Western Med.	2021	MUT_1	Red mullet in GSA 1	2022	No	STECF
Western Med.	2020	MUT_10	Red mullet in GSA 10	2022	No	GFCM
Western Med.	2021	MUT_6	Red mullet in GSA 6	2022	No	STECF
Western Med.	2021	MUT_7	Red mullet in GSA 7	2022	No	STECF
Western Med.	2021	MUT_9	Red mullet in GSA 9	2022	No	STECF
Western Med.	2020	NEP_5	Norway lobster in GSA 5	2022	Yes	GFCM

Western Med.	2021	NEP_6	Norway lobster in GSA 6	2022	No	STECF
Western Med.	2021	NEP_9	Norway lobster in GSA 9	2022	No	STECF
Western Med.	2019	PIL_1	European pilchard(=Sardine) in GSA 1	2021	No	GFCM
Western Med.	2020	PIL_6	European pilchard(=Sardine) in GSA 6	2022	No	GFCM
Western Med.	2020	PIL_7	European pilchard(=Sardine) in GSA 7	2022	No	GFCM
Western Med.	2020	PIL_9	European pilchard(=Sardine) in GSA 9	2022	Yes	GFCM
Western Med.	2020	SBR_1_3	Blackspot(=red) seabream in GSA 1, 3	2022	Yes	GFCM

4.1 Indicators of management performance

4.1.1 Trend in F/F_{MSY}

To compute this indicator, a similar model to the respective one used in the North East Atlantic was used, namely a mixed linear model, described in the protocol (Annex 1). Values for 2021 were removed from the model fit. Bootstrapped quantiles of F/F_{MSY} are displayed in Figure 20 and Table 19. The 50% quantile (black line, equivalent to the median) indicates a peak in 2010 with a prior rise and subsequent general decline, though from the uncertainty estimates the observed pattern is unlikely to be significant. The uncertainty in the 2020 value is underestimated due to having four stocks for which constant F was assumed in 2019-2020, as per the protocol.

The scale of the indicator suggests that exploitation has been at roughly twice the level of the CFP management objectives. With the exception of 2018 and 19 there is a near linear decline in the instantaneous exploitation rate, but uncertainty and data assumptions make it impossible to interpret the median trend as management, or covid-effects. In contrast, the regional deterministic indicators (Figure 21) consistently indicate a decline in exploitation rate from 2019 to 2020 in all regions suggesting that the decline in the final year is likely real.

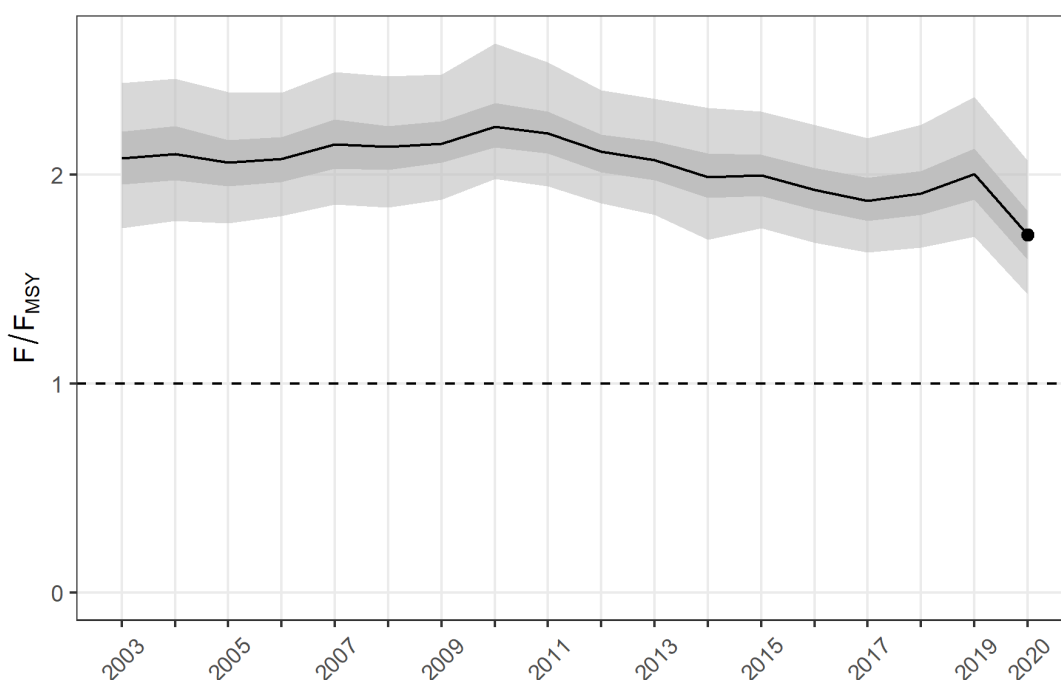


Figure 20: Trend in F/F_{MSY} (based on 57 stocks). Dark grey zone shows the 50% confidence interval; the light grey zone shows the 95% confidence interval.

Table 19: Percentiles for F/F_{MSY}

Percentiles	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
2.5%	1.74	1.78	1.77	1.80	1.86	1.84	1.88	1.98	1.94	1.86
25%	1.95	1.97	1.94	1.96	2.03	2.02	2.06	2.13	2.10	2.01
50%	2.08	2.10	2.06	2.07	2.14	2.13	2.15	2.23	2.20	2.11
75%	2.20	2.23	2.16	2.18	2.26	2.23	2.25	2.34	2.30	2.19
97.5%	2.44	2.46	2.39	2.39	2.49	2.47	2.48	2.63	2.54	2.40

Percentiles	2013	2014	2015	2016	2017	2018	2019	2020	2021
2.5%	1.81	1.69	1.74	1.67	1.63	1.65	1.70	1.43	-
25%	1.97	1.89	1.90	1.83	1.78	1.81	1.88	1.59	-
50%	2.07	1.99	2.00	1.93	1.87	1.91	2.00	1.71	-
75%	2.16	2.10	2.10	2.03	1.98	2.02	2.12	1.82	-
97.5%	2.36	2.32	2.30	2.24	2.17	2.24	2.37	2.07	-

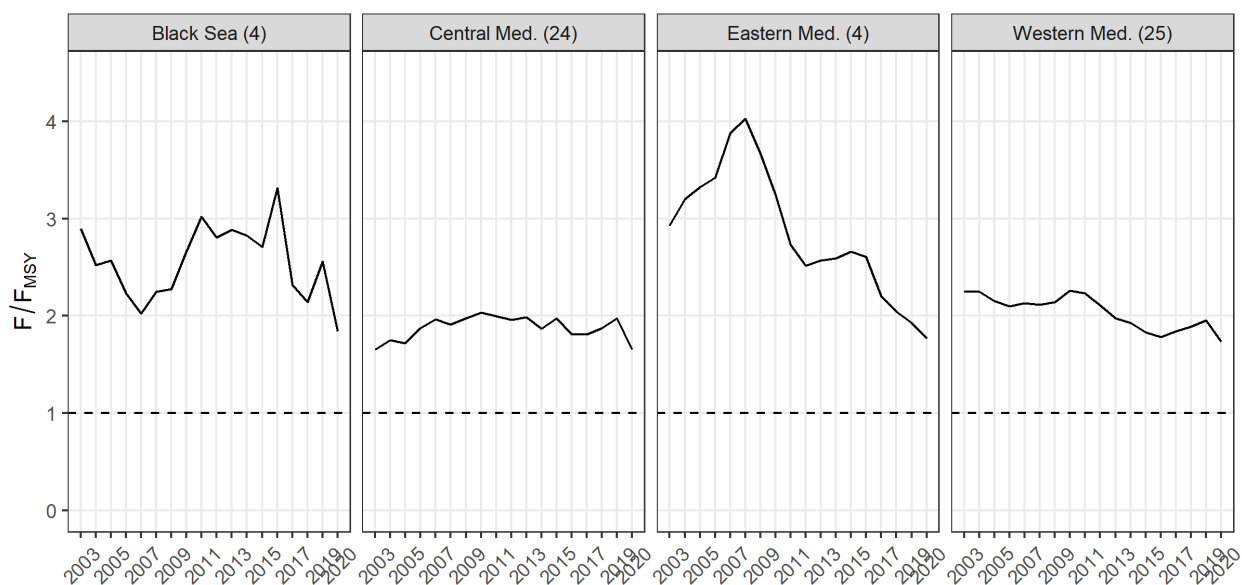


Figure 21: Trend in F/F_{MSY} by ecoregion. The number of stocks in each ecoregion are shown between parentheses.

Table 20: F/F_{MSY} by ecoregion

EcoRegion	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Black Sea	2.90	2.52	2.57	2.23	2.02	2.25	2.27	2.66	3.02	2.81
Central Med.	1.65	1.75	1.72	1.87	1.96	1.91	1.97	2.04	2	1.96
Eastern Med.	2.93	3.2	3.32	3.42	3.88	4.03	3.67	3.25	2.73	2.51
Western Med.	2.25	2.25	2.15	2.1	2.13	2.11	2.14	2.26	2.23	2.11

EcoRegion	2013	2014	2015	2016	2017	2018	2019	2020	2021
Black Sea	2.89	2.83	2.71	3.31	2.32	2.14	2.56	1.84	-
Central Med.	1.99	1.87	1.97	1.81	1.81	1.87	1.98	1.66	-
Eastern Med.	2.57	2.59	2.66	2.61	2.21	2.04	1.93	1.77	-
Western Med.	1.98	1.93	1.83	1.78	1.84	1.89	1.95	1.73	-

4.1.2 Trend in SSB (relative to SSB in 2003)

This indicator was computed with a similar model to those in the North East Atlantic, namely a mixed linear model, described in the protocol (Annex 1). The 50% quantile (black line), suggests SSB in 2019 was at similar levels to 2003 having recovered from reduced levels over 2011-2013. The final year in the analysis provides some indication of improving trend in SSB (Figure 22 and Table 21). Quantiles are tighter than in previous analyses reflecting the greater number of stocks used this year, but change in the deviance component ratio by the GLMM model cannot be excluded as a contributing factor. The trends estimated by Ecoregion (Figure 23 and Table 22) show substantial differences in trend between ecoregions, variable but stable in the Black Sea, decreasing in the central Med and increasing in the eastern Med. In the western Med it has been increasing since 2011 after an earlier decline.

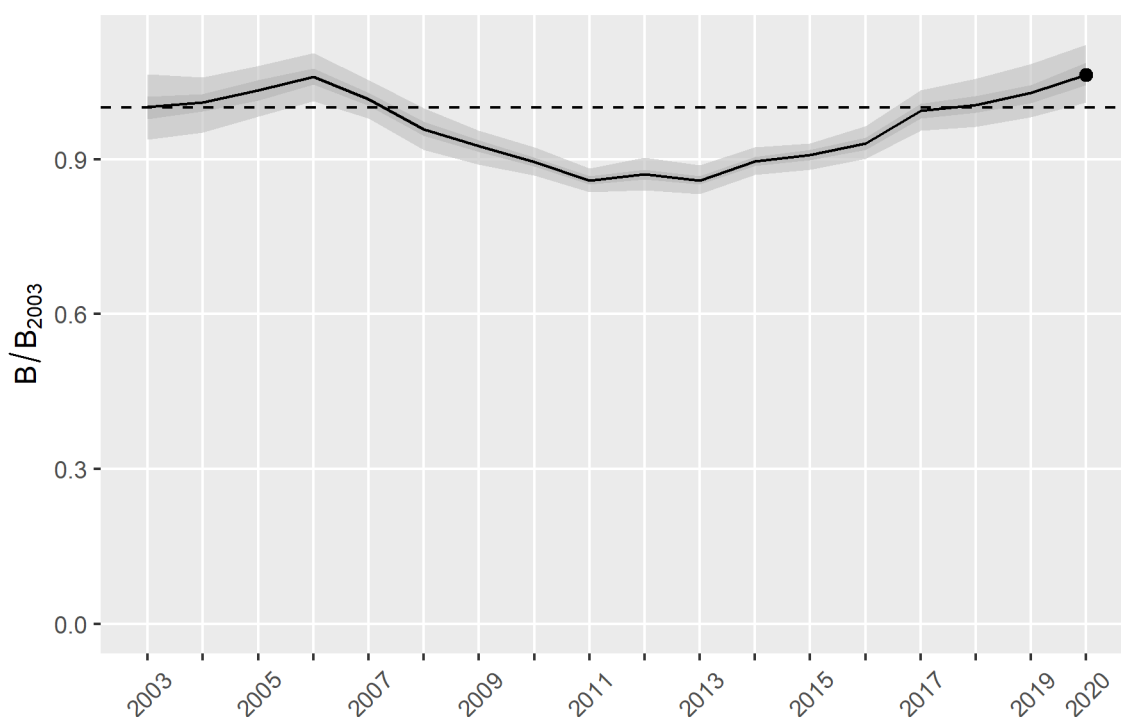


Figure 22: Trend in SSB relative to 2003 (based on 58 stocks). Dark grey zone shows the 50% confidence interval; the light grey zone shows the 95% confidence interval.

Table 21: Percentiles for SSB relative to 2003

Percentiles	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
2.5%	0.94	0.95	0.98	1.01	0.98	0.92	0.89	0.87	0.84	0.84
25%	0.98	0.99	1.01	1.04	1.00	0.94	0.91	0.89	0.85	0.86
50%	1.00	1.01	1.03	1.06	1.02	0.96	0.93	0.89	0.86	0.87
75%	1.02	1.03	1.05	1.08	1.03	0.97	0.94	0.90	0.87	0.88
97.5%	1.06	1.06	1.08	1.10	1.05	1.00	0.96	0.92	0.88	0.90

Percentiles	2013	2014	2015	2016	2017	2018	2019	2020	2021
2.5%	0.83	0.87	0.88	0.90	0.96	0.96	0.98	1.01	-
25%	0.85	0.89	0.90	0.92	0.98	0.99	1.01	1.04	-
50%	0.86	0.90	0.91	0.93	0.99	1.00	1.03	1.06	-
75%	0.87	0.90	0.92	0.94	1.01	1.02	1.04	1.09	-
97.5%	0.89	0.92	0.93	0.96	1.03	1.06	1.08	1.12	-

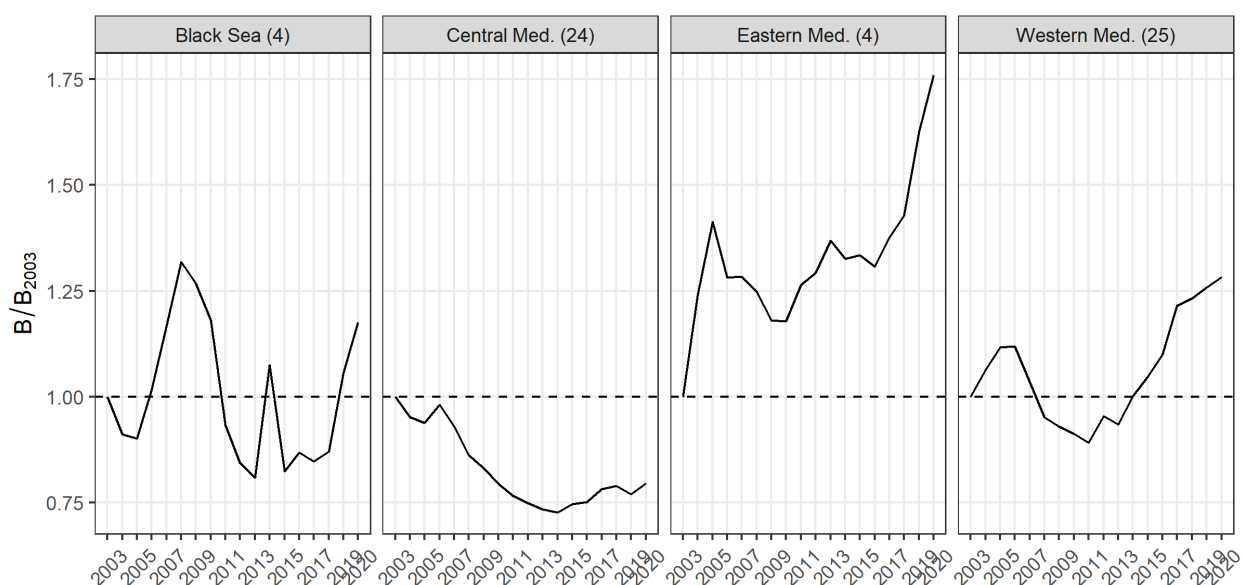


Figure 23: Trend in SSB relative to 2003 by ecoregion. The number of stocks in each ecoregion are shown in parentheses.

Table 22: SSB relative to 2003 by ecoregion

EcoRegion	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Black Sea	1.00	0.91	0.90	1.02	1.17	1.32	1.27	1.18	0.93	0.84
Central Med.	1.00	0.95	0.94	0.98	0.93	0.86	0.83	0.79	0.77	0.75
Eastern Med.	1.00	1.24	1.41	1.28	1.28	1.25	1.18	1.18	1.26	1.29
Western Med.	1.00	1.06	1.12	1.12	1.03	0.95	0.93	0.91	0.89	0.95

EcoRegion	2013	2014	2015	2016	2017	2018	2019	2020	2021
Black Sea	0.81	1.07	0.82	0.87	0.85	0.87	1.06	1.18	-
Central Med.	0.73	0.73	0.75	0.75	0.78	0.79	0.77	0.8	-
Eastern Med.	1.37	1.33	1.33	1.31	1.38	1.43	1.63	1.76	-
Western Med.	0.93	1.00	1.05	1.10	1.22	1.23	1.26	1.28	-

4.2 Indicators of advice coverage

In the Mediterranean and Black Seas a total of 262 possible stocks were considered for the analysis; 230 stocks fell within the Mediterranean and Black Sea sampling frame and 32 stocks were analytically assessed but not in the sampling frame (see the protocol in Annex 1 and Mannini et al., 2017). Of these, 96 were covered by stock assessments carried out between 2020 and 2022. In some cases, multiple stocks were aggregated in a single multi-area stock assessment, in which case all stocks in the stock list are accounted for, hence why 58 stock assessments cover 96 stocks. The advice coverage for the Mediterranean and the Black Sea was 0.37.

Table 23: List of stock assessments included in addition to those in the sampling frame

ARA 2	ARA 7	ARA 10	ARA 18	ARA 20
ARS 9	ARS 18	ARS 20	DPS 5	DPS 6
DPS 7	DPS 8	DPS 11	DPS 12	DPS 13
DPS 14	DPS 15	DPS 17	HKE 8	HKE 12
HKE 13	HKE 14	HKE 15	MUT 1	MUT 7
MUT 10	MUT 15	MUT 19	NEP 5	NEP 15
SBR 3	WHG 29			

5 EUROPEAN UNION WATERS

STECF was requested in 2021 to provide two indicators of performance for the CFP at the European level (STECF, 2021a). The same model as in the individual areas was applied to the Northeast Atlantic and the Mediterranean and Black Seas combined to provide estimates of F/F_{MSY} and B/B_{2003} (indicators 7 and 8 of the protocol). For the purpose of deriving this index, the Northeast Atlantic and the Mediterranean and Black Seas datasets were pooled together and used as input data (Figure 24, Figure 25, Figure 26 and Figure 27). The time window was reduced by one year (2003-2020) in comparison to the Northeast Atlantic analysis as the Mediterranean and Black Seas dataset stops in 2020.

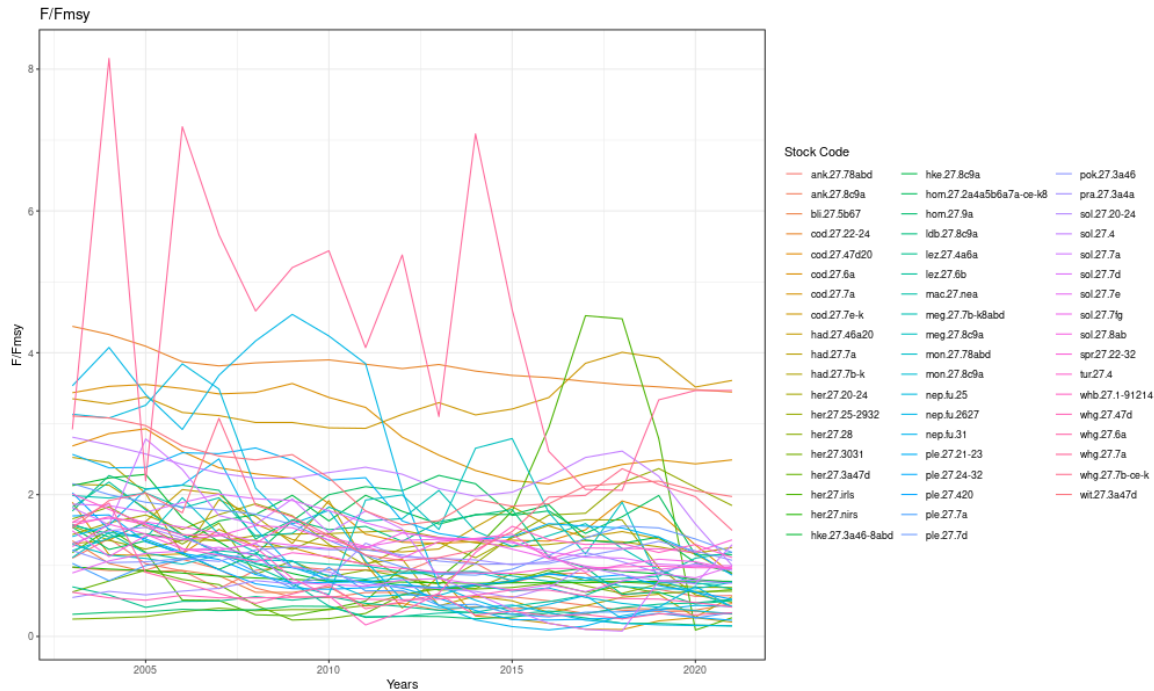


Figure 24: Individual trajectories of all stocks used to estimate the F/F_{MSY} indicator for the Northeast Atlantic

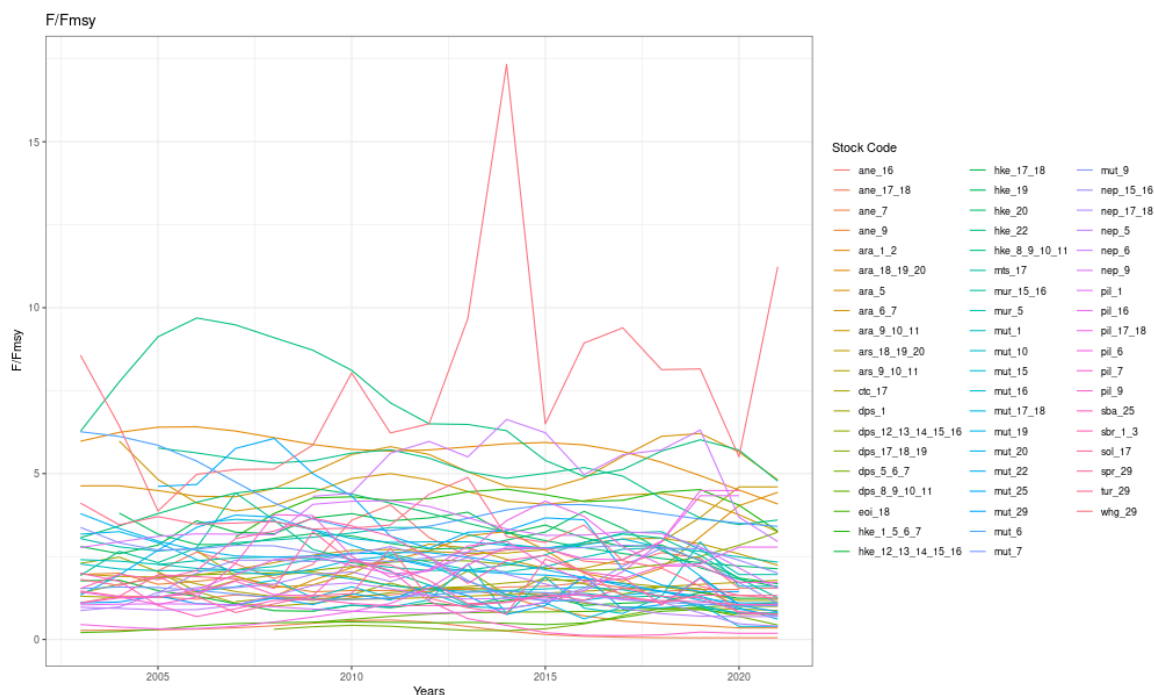


Figure 25: Individual trajectories of all stocks used to estimate the F/F_{MSY} indicator for the Mediterranean and Black Seas

5.1 Indicators of management performance

Trends in F/F_{MSY} in EU Waters (FAO 27 and 37) exhibited a decreasing trend from 2003 to 2020 (Figure 26 and Table 24). The steepness of the decrease was higher over the years 2003-2013 than in the period 2013-2019 at the end of which it was 1.35. The ratio then exhibited a decrease to 1.17 in 2020.

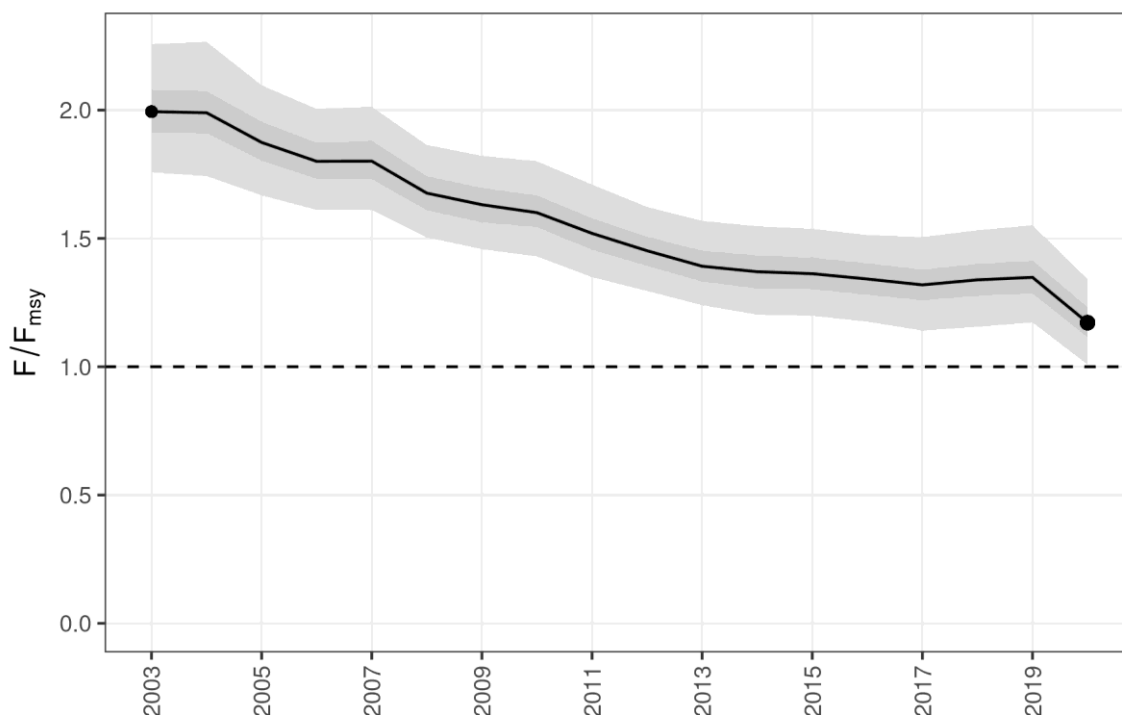


Figure 26: Trends in F/F_{MSY} (based on 114 stocks, 57 from the Northeast Atlantic and 57 from the Mediterranean and Black Seas). The dark grey zone shows the 50% confidence interval; the light grey zone shows the 95% confidence interval.

Table 24: Percentiles of F/F_{MSY} by year

EcoRegion	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
2.5%	1.76	1.74	1.67	1.61	1.61	1.50	1.46	1.43	1.35	1.29
25%	1.91	1.91	1.80	1.73	1.73	1.61	1.56	1.55	1.46	1.39
50%	1.99	1.99	1.87	1.80	1.80	1.68	1.63	1.60	1.52	1.45
75%	2.08	2.07	1.95	1.87	1.88	1.74	1.70	1.67	1.58	1.51
97.5%	2.26	2.27	2.10	2.00	2.01	1.86	1.82	1.80	1.71	1.62

EcoRegion	2013	2014	2015	2016	2017	2018	2019	2020	2021
2.5%	1.24	1.20	1.20	1.18	1.14	1.16	1.17	1.01	-
25%	1.33	1.31	1.30	1.28	1.26	1.28	1.29	1.12	-
50%	1.39	1.37	1.36	1.34	1.32	1.34	1.35	1.17	-
75%	1.45	1.43	1.42	1.40	1.38	1.40	1.41	1.23	-
97.5%	1.57	1.55	1.54	1.51	1.51	1.53	1.55	1.34	-

Trends in B/B_{2003} decreased over the years 2003-2009 to reach 0.93 (Figure 27 and Table 25). It then followed a global increasing trend until 2020 when it reached 1.18, the maximum of the series. A convergence warning was issued when fitting this indicator. The max absolute value of the gradient reached 0.03.

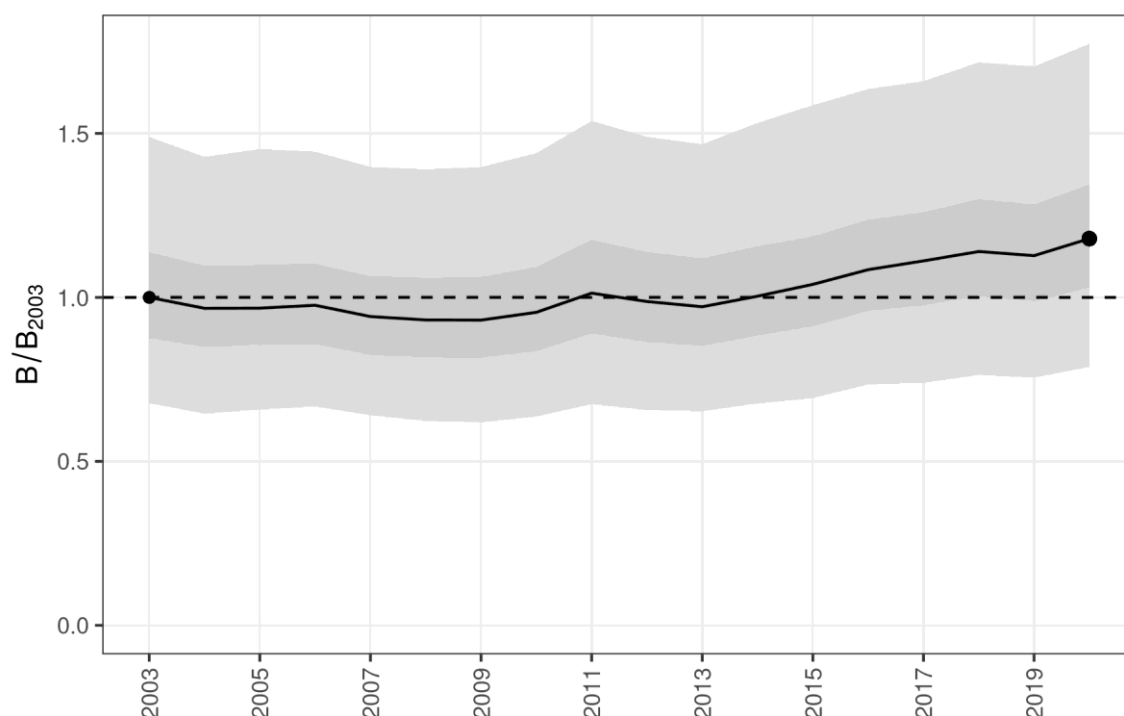


Figure 27: Trends in B/B_{2003} (based on 113 stocks, 55 from the Northeast Atlantic and 58 from the Mediterranean and Black Seas). The dark grey zone shows the 50% confidence interval; the light grey zone shows the 95% confidence interval.

Table 25: Percentiles of SSB relative to 2003

EcoRegion	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
2.5%	0.68	0.65	0.66	0.67	0.64	0.62	0.62	0.64	0.67	0.66
25%	0.88	0.85	0.86	0.86	0.83	0.82	0.82	0.84	0.89	0.86
50%	1.00	0.97	0.97	0.98	0.94	0.93	0.93	0.95	1.01	0.99
75%	1.14	1.10	1.10	1.10	1.06	1.06	1.06	1.09	1.17	1.14
97.5%	1.49	1.43	1.45	1.44	1.40	1.39	1.40	1.44	1.54	1.49

EcoRegion	2013	2014	2015	2016	2017	2018	2019	2020	2021
2.5%	0.65	0.68	0.69	0.73	0.74	0.76	0.76	0.79	-
25%	0.85	0.88	0.91	0.96	0.98	1.01	0.99	1.03	-
50%	0.97	1.00	1.04	1.08	1.11	1.14	1.13	1.18	-
75%	1.12	1.16	1.19	1.24	1.26	1.30	1.28	1.34	-
97.5%	1.47	1.53	1.59	1.64	1.66	1.72	1.70	1.77	-

6 STATUS ACROSS ALL STOCKS

Table 26: Stock status for all stocks in the analysis. Columns refer to ecoregion, last year for which the estimate was obtained, stock code description, value for F/F_{MSY} ratio (F_{ind}), if F is lower than F_{MSY} (F Status), if the stock is inside safe biological limits (SBL) (for both indicators F_{PA} and B_{PA}), and if the stock has F below F_{MSY} and SSB above B_{MSY} ($F \leq F_{MSY}$ and $B \geq B_{MSY}$). Stocks managed under escapement strategies do not have an estimate of F/F_{MSY} , their F status is calculated as $MSYB_{escapement}$ over the stock size. Symbol 'Y' stands for 'Yes', 'N' for No and '-' stands for unknown due to missing information.

Region	EcoRegion	Year	Stock	Description	F_{ind}	F status	SBL	CFP
FAO27	Baltic Sea	2021	cod.27.22-24	Cod (<i>Gadus morhua</i>) in subdivisions 22-24. western Baltic stock (western Baltic Sea)	3.45	N	N	-
FAO27	Baltic Sea	2021	her.27.20-24	Herring (<i>Clupea harengus</i>) in subdivisions 20-24. spring spawners (Skagerrak. Kattegat. and western Baltic)	0.48	Y	N	-
FAO27	Baltic Sea	2021	her.27.25-2932	Herring (<i>Clupea harengus</i>) in subdivisions 25-29 and 32. excluding the Gulf of Riga (central Baltic Sea)	1.85	N	N	-
FAO27	Baltic Sea	2021	her.27.28	Herring (<i>Clupea harengus</i>) in Subdivision 28.1 (Gulf of Riga)	0.69	Y	Y	Y
FAO27	Baltic Sea	2021	her.27.3031	Herring (<i>Clupea harengus</i>) in subdivisions 30 and 31 (Gulf of Bothnia)	0.66	Y	Y	-
FAO27	Baltic Sea	2021	ple.27.21-23	Plaice (<i>Pleuronectes platessa</i>) in subdivisions 21-23 (Kattegat. Belt Seas. and the Sound)	0.86	Y	Y	-
FAO27	Baltic Sea	2021	ple.27.24-32	Plaice (<i>Pleuronectes platessa</i>) in subdivisions 24-32 (Baltic Sea. excluding the Sound and Belt Seas)	0.23	Y	-	Y
FAO27	Baltic Sea	2021	sol.27.20-24	Sole (<i>Solea solea</i>) in subdivisions 20-24 (Skagerrak and Kattegat. western Baltic Sea)	0.75	Y	Y	-
FAO27	Baltic Sea	2021	spr.27.22-32	Sprat (<i>Sprattus sprattus</i>) in subdivisions 22-32 (Baltic Sea)	1.36	N	N	-
FAO27	BoBiscay & Iberia	2021	ane.27.8	Anchovy (<i>Engraulis encrasicolus</i>) in Subarea 8 (Bay of Biscay)	-	Y	-	-
FAO27	BoBiscay & Iberia	2021	ank.27.78abd	Black-bellied anglerfish (<i>Lophius budegassa</i>) in Subarea 7 and divisions 8.a-b and 8.d (Celtic Seas. Bay of Biscay)	0.58	Y	Y	-
FAO27	BoBiscay & Iberia	2021	ank.27.8c9a	Black-bellied anglerfish (<i>Lophius budegassa</i>) in divisions 8.c and 9.a (Cantabrian Sea. Atlantic Iberian waters)	0.32	Y	-	Y
FAO27	BoBiscay & Iberia	2021	hke.27.8c9a	Hake (<i>Merluccius merluccius</i>) in divisions 8.c and 9.a. Southern stock (Cantabrian Sea and Atlantic Iberian waters)	0.90	Y	Y	-

Region	EcoRegion	Year	Stock	Description	F ind	F status	SBL	CFP
FAO27	BoBiscay & Iberia	2021	hom.27.9a	Horse mackerel (<i>Trachurus trachurus</i>) in Division 9.a (Atlantic Iberian waters)	0.15	Y	-	Y
FAO27	BoBiscay & Iberia	2021	ldb.27.8c9a	Four-spot megrim (<i>Lepidorhombus boscii</i>) in divisions 8.c and 9.a (southern Bay of Biscay and Atlantic Iberian waters East)	0.51	Y	Y	-
FAO27	BoBiscay & Iberia	2021	meg.27.7b-k8abd	Megrim (<i>Lepidorhombus whiffiagonis</i>) in divisions 7.b-k. 8.a-b. and 8.d (west and southwest of Ireland. Bay of Biscay)	0.77	Y	Y	-
FAO27	BoBiscay & Iberia	2021	meg.27.8c9a	Megrim (<i>Lepidorhombus whiffiagonis</i>) in divisions 8.c and 9.a (Cantabrian Sea and Atlantic Iberian waters)	0.42	Y	Y	-
FAO27	BoBiscay & Iberia	2021	mon.27.78abd	White anglerfish (<i>Lophius piscatorius</i>) in Subarea 7 and divisions 8.a-b and 8.d (Celtic Seas. Bay of Biscay)	0.77	Y	Y	-
FAO27	BoBiscay & Iberia	2021	mon.27.8c9a	White anglerfish (<i>Lophius piscatorius</i>) in divisions 8.c and 9.a (Cantabrian Sea and Atlantic Iberian waters)	0.32	Y	Y	Y
FAO27	BoBiscay & Iberia	2021	nep.fu.2324	Norway lobster (<i>Nephrops norvegicus</i>) in divisions 8.a and 8.b. Functional Units 23-24 (northern and central Bay of Biscay)	0.70	Y	-	-
FAO27	BoBiscay & Iberia	2021	nep.fu.25	Norway lobster (<i>Nephrops norvegicus</i>) in Division 8.c. Functional Unit 25 (southern Bay of Biscay and northern Galicia)	0.15	Y	-	N
FAO27	BoBiscay & Iberia	2021	nep.fu.2627	Norway lobster (<i>Nephrops norvegicus</i>) in Division 9.a. Functional Units 26-27 (Atlantic Iberian waters East. western Galicia. and northern Portugal)	0.41	Y	-	N
FAO27	BoBiscay & Iberia	2021	nep.fu.31	Norway lobster (<i>Nephrops norvegicus</i>) in Division 8.c. Functional Unit 31 (southern Bay of Biscay and Cantabrian Sea)	0.42	Y	-	N
FAO27	BoBiscay & Iberia	2021	sol.27.8ab	Sole (<i>Solea solea</i>) in divisions 8.a-b (northern and central Bay of Biscay)	0.95	Y	Y	-
FAO27	Celtic Seas	2021	cod.27.6a	Cod (<i>Gadus morhua</i>) in Division 6.a (West of Scotland)	2.49	N	N	-
FAO27	Celtic Seas	2021	cod.27.7a	Cod (<i>Gadus morhua</i>) in Division 7.a (Irish Sea)	0.20	Y	N	-
FAO27	Celtic Seas	2021	cod.27.7e-k	Cod (<i>Gadus morhua</i>) in divisions 7.e-k (eastern English Channel and southern Celtic Seas)	3.61	N	N	-
FAO27	Celtic Seas	2021	had.27.7a	Haddock (<i>Melanogrammus aeglefinus</i>) in Division 7.a (Irish Sea)	0.56	Y	Y	Y
FAO27	Celtic Seas	2021	had.27.7b-k	Haddock (<i>Melanogrammus aeglefinus</i>) in divisions 7.b-k (southern Celtic Seas and English Channel)	1.25	N	Y	-
FAO27	Celtic Seas	2021	her.27.irls	Herring (<i>Clupea harengus</i>) in divisions 7.a South of 52°30'N. 7.g-h. and 7.j-k (Irish Sea. Celtic Sea. and southwest of Ireland)	0.26	Y	N	-
FAO27	Celtic Seas	2021	her.27.nirs	Herring (<i>Clupea harengus</i>) in Division 7.a North of 52°30'N (Irish Sea)	0.78	Y	Y	-

Region	EcoRegion	Year	Stock	Description	F ind	F status	SBL	CFP
FAO27	Celtic Seas	2021	lez.27.4a6a	Megrim (<i>Lepidorhombus</i> spp.) in divisions 4.a and 6.a (northern North Sea. West of Scotland)	0.52	Y	-	Y
FAO27	Celtic Seas	2021	lez.27.6b	Megrim (<i>Lepidorhombus</i> spp.) in Division 6.b (Rockall)	0.67	Y	-	Y
FAO27	Celtic Seas	2021	nep.fu.11	Norway lobster (<i>Nephrops norvegicus</i>) in Division 6.a. Functional Unit 11 (West of Scotland. North Minch)	0.43	Y	-	Y
FAO27	Celtic Seas	2021	nep.fu.12	Norway lobster (<i>Nephrops norvegicus</i>) in Division 6.a. Functional Unit 12 (West of Scotland. South Minch)	0.64	Y	-	Y
FAO27	Celtic Seas	2021	nep.fu.13	Norway lobster (<i>Nephrops norvegicus</i>) in Division 6.a. Functional Unit 13 (West of Scotland. the Firth of Clyde and Sound of Jura)	1.36	N	-	N
FAO27	Celtic Seas	2021	nep.fu.14	Norway lobster (<i>Nephrops norvegicus</i>) in Division 7.a. Functional Unit 14 (Irish Sea. East)	0.56	Y	-	Y
FAO27	Celtic Seas	2021	nep.fu.15	Norway lobster (<i>Nephrops norvegicus</i>) in Division 7.a. Functional Unit 15 (Irish Sea. West)	0.68	Y	-	Y
FAO27	Celtic Seas	2021	nep.fu.16	Norway lobster (<i>Nephrops norvegicus</i>) in divisions 7.b-c and 7.j-k. Functional Unit 16 (west and southwest of Ireland. Porcupine Bank)	0.92	Y	-	-
FAO27	Celtic Seas	2021	nep.fu.17	Norway lobster (<i>Nephrops norvegicus</i>) in Division 7.b. Functional Unit 17 (west of Ireland. Aran grounds)	1.00	Y	-	N
FAO27	Celtic Seas	2021	nep.fu.19	Norway lobster (<i>Nephrops norvegicus</i>) in divisions 7.a. 7.g. and 7.j. Functional Unit 19 (Irish Sea. Celtic Sea. eastern part of southwest of Ireland)	0.96	Y	-	N
FAO27	Celtic Seas	2021	nep.fu.2021	Norway lobster (<i>Nephrops norvegicus</i>) in divisions 7.g and 7.h. Functional Units 20 and 21 (Celtic Sea)	0.34	Y	-	Y
FAO27	Celtic Seas	2021	nep.fu.22	Norway lobster (<i>Nephrops norvegicus</i>) in divisions 7.f and 7.g. Functional Unit 22 (Celtic Sea. Bristol Channel)	0.83	Y	-	N
FAO27	Celtic Seas	2021	ple.27.7a	Plaice (<i>Pleuronectes platessa</i>) in Division 7.a (Irish Sea)	0.34	Y	Y	Y
FAO27	Celtic Seas	2021	rju.27.7de	Undulate ray (<i>Raja undulata</i>) in divisions 7.d and 7.e (English Channel)	0.08	Y	-	Y
FAO27	Celtic Seas	2021	sol.27.7a	Sole (<i>Solea solea</i>) in Division 7.a (Irish Sea)	1.30	N	N	-
FAO27	Celtic Seas	2021	sol.27.7e	Sole (<i>Solea solea</i>) in Division 7.e (western English Channel)	0.99	Y	Y	Y
FAO27	Celtic Seas	2021	sol.27.7fg	Sole (<i>Solea solea</i>) in divisions 7.f and 7.g (Bristol Channel. Celtic Sea)	1.00	Y	Y	-
FAO27	Celtic Seas	2021	whg.27.6a	Whiting (<i>Merlangius merlangus</i>) in Division 6.a (West of Scotland)	0.33	Y	Y	-
FAO27	Celtic Seas	2020	whg.27.7a	Whiting (<i>Merlangius merlangus</i>) in Division 7.a (Irish Sea)	3.47	N	N	-

Region	EcoRegion	Year	Stock	Description	F ind	F status	SBL	CFP
FAO27	Celtic Seas	2021	whg.27.7b-ce-k	Whiting (<i>Merlangius merlangus</i>) in divisions 7.b-c and 7.e-k (southern Celtic Seas and eastern English Channel)	1.50	N	N	-
FAO27	Greater North Sea	2021	cod.27.47d20	Cod (<i>Gadus morhua</i>) in Subarea 4. Division 7.d. and Subdivision 20 (North Sea. eastern English Channel. Skagerrak)	0.88	Y	N	-
FAO27	Greater North Sea	2021	had.27.46a20	Haddock (<i>Melanogrammus aeglefinus</i>) in Subarea 4. Division 6.a. and Subdivision 20 (North Sea. West of Scotland. Skagerrak)	0.88	Y	Y	-
FAO27	Greater North Sea	2021	her.27.3a47d	Herring (<i>Clupea harengus</i>) in Subarea 4 and divisions 3.a and 7.d. autumn spawners (North Sea. Skagerrak and Kattegat. eastern English Channel)	0.64	Y	Y	Y
FAO27	Greater North Sea	2021	nep.fu.3-4	Norway lobster (<i>Nephrops norvegicus</i>) in Division 3.a. Functional units 3 and 4 (Skagerrak and Kattegat)	0.64	Y	-	-
FAO27	Greater North Sea	2021	nep.fu.6	Norway lobster (<i>Nephrops norvegicus</i>) in Division 4.b. Functional Unit 6 (central North Sea. Farn Deep)	1.47	N	-	N
FAO27	Greater North Sea	2021	nep.fu.7	Norway lobster (<i>Nephrops norvegicus</i>) in Division 4.a. Functional Unit 7 (northern North Sea. Fladen Ground)	0.62	Y	-	Y
FAO27	Greater North Sea	2021	nep.fu.8	Norway lobster (<i>Nephrops norvegicus</i>) in Division 4.b. Functional Unit 8 (central North Sea. Firth of Forth)	0.66	Y	-	Y
FAO27	Greater North Sea	2021	nep.fu.9	Norway lobster (<i>Nephrops norvegicus</i>) in Division 4.a. Functional Unit 9 (central North Sea. Moray Firth)	0.54	Y	-	Y
FAO27	Greater North Sea	2021	nop.27.3a4	Norway pout (<i>Trisopterus esmarkii</i>) in Subarea 4 and Division 3.a (North Sea. Skagerrak and Kattegat)	-	N	-	-
FAO27	Greater North Sea	2021	ple.27.420	Plaice (<i>Pleuronectes platessa</i>) in Subarea 4 (North Sea) and Subdivision 20 (Skagerrak)	0.52	Y	Y	-
FAO27	Greater North Sea	2021	ple.27.7d	Plaice (<i>Pleuronectes platessa</i>) in Division 7.d (eastern English Channel)	1.19	N	N	-
FAO27	Greater North Sea	2021	pok.27.3a46	Saithe (<i>Pollachius virens</i>) in subareas 4. 6 and Division 3.a (North Sea. Rockall and West of Scotland. Skagerrak and Kattegat)	1.07	N	N	-
FAO27	Greater North Sea	2021	pra.27.3a4a	Northern shrimp (<i>Pandalus borealis</i>) in divisions 3.a and 4.a East (Skagerrak and Kattegat and northern North Sea in the Norwegian Deep)	0.93	Y	-	N
FAO27	Greater North Sea	2021	san.sa.1r	Sandeel (<i>Ammodytes spp.</i>) in divisions 4.b and 4.c. Sandeel Area 1r (central and southern North Sea. Dogger Bank)	-	N	-	-

Region	EcoRegion	Year	Stock	Description	F ind	F status	SBL	CFP
FAO27	Greater North Sea	2021	san.sa.2r	Sandeel (<i>Ammodytes spp.</i>) in divisions 4.b and 4.c. and Subdivision 20. Sandeel Area 2r (Skagerrak. central and southern North Sea)	-	N	-	-
FAO27	Greater North Sea	2021	san.sa.3r	Sandeel (<i>Ammodytes spp.</i>) in divisions 4.a and 4.b. and Subdivision 20. Sandeel Area 3r (Skagerrak. northern and central North Sea)	-	Y	-	-
FAO27	Greater North Sea	2021	san.sa.4	Sandeel (<i>Ammodytes spp.</i>) in divisions 4.a and 4.b. Sandeel Area 4 (northern and central North Sea)	-	Y	-	-
FAO27	Greater North Sea	2021	sol.27.4	Sole (<i>Solea solea</i>) in Subarea 4 (North Sea)	1.00	N	Y	-
FAO27	Greater North Sea	2021	sol.27.7d	Sole (<i>Solea solea</i>) in Division 7.d (eastern English Channel)	0.96	Y	N	-
FAO27	Greater North Sea	2021	spr.27.3a4	Sprat (<i>Sprattus sprattus</i>) in Division 3.a and Subarea 4 (Skagerrak. Kattegat and North Sea)	-	Y	-	-
FAO27	Greater North Sea	2021	tur.27.4	Turbot (<i>Scophthalmus maximus</i>) in Subarea 4 (North Sea)	0.97	Y	Y	Y
FAO27	Greater North Sea	2021	whg.27.47d	Whiting (<i>Merlangius merlangus</i>) in Subarea 4 and Division 7.d (North Sea and eastern English Channel)	0.41	Y	Y	-
FAO27	Greater North Sea	2021	wit.27.3a47d	Witch (<i>Glyptocephalus cynoglossus</i>) in Subarea 4 and divisions 3.a and 7.d (North Sea. Skagerrak and Kattegat. eastern English Channel)	1.97	N	N	-
FAO27	Widely	2021	bli.27.5b67	Blue ling (<i>Molva dypterygia</i>) in subareas 6-7 and Division 5.b (Celtic Seas and Faroes grounds)	0.46	Y	Y	-
FAO27	Widely	2021	dgs.27.nea	Spurdog (<i>Squalus acanthias</i>) in subareas 1-10. 12 and 14 (the Northeast Atlantic and adjacent waters)	0.07	Y	Y	-
FAO27	Widely	2021	hke.27.3a46-8abd	Hake (<i>Merluccius merluccius</i>) 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)	0.77	Y	Y	-
FAO27	Widely	2021	hom.27.2a4a5b6a7a-ce-k8	Horse mackerel (<i>Trachurus trachurus</i>) in Subarea 8 and divisions 2.a. 4.a. 5.b. 6.a. 7.a-c.e-k (the Northeast Atlantic)	1.15	N	N	-
FAO27	Widely	2021	mac.27.nea	Mackerel (<i>Scomber scombrus</i>) in subareas 1-8 and 14 and Division 9.a (the Northeast Atlantic and adjacent waters)	1.19	N	Y	-
FAO27	Widely	2021	por.27.nea	Porbeagle (<i>Lamna nasus</i>) in subareas 1-10. 12 and 14 (the Northeast Atlantic and adjacent waters)	0.01	Y	-	N
FAO27	Widely	2021	whb.27.1-91214	Blue whiting (<i>Micromesistius poutassou</i>) in subareas 1-9. 12. and 14 (Northeast Atlantic and adjacent waters)	1.11	N	N	-

Region	EcoRegion	Year	Stock	Description	F ind	F status	SBL	CFP
FAO37	Black Sea	2021	mut_29	Red mullet in GSA 29	0.83	Y	-	-
FAO37	Black Sea	2020	spr_29	European sprat in GSA 29	1.33	N	-	-
FAO37	Black Sea	2021	tur_29	Turbot in GSA 29	1.24	N	-	-
FAO37	Black Sea	2021	whg_29	Whiting in GSA 29	11.23	N	-	-
FAO37	Central Med.	2020	ane_16	European anchovy in GSA 16	1.55	N	-	-
FAO37	Central Med.	2019	ane_17_18	European anchovy in GSA 17, 18	1.51	N	-	-
FAO37	Central Med.	2021	ara_18_19_20	Blue and red shrimp in GSA 18, 19, 20	4.44	N	-	-
FAO37	Central Med.	2021	ars_18_19_20	Giant red shrimp in GSA 18, 19, 20	2.24	N	-	-
FAO37	Central Med.	2020	ctc_17	Common cuttlefish in GSA 17	1.18	N	-	-
FAO37	Central Med.	2020	dps_12_13_14_15_16	Deep-water rose shrimp in GSA 12, 13, 14, 15, 16	1.00	Y	-	-
FAO37	Central Med.	2021	dps_17_18_19	Deep-water rose shrimp in GSA 17, 18, 19	3.24	N	-	-
FAO37	Central Med.	2020	eoi_18	Horned octopus in GSA 18	0.77	Y	-	-
FAO37	Central Med.	2020	hke_12_13_14_15_16	European hake in GSA 12, 13, 14, 15, 16	1.24	N	-	-
FAO37	Central Med.	2021	hke_17_18	European hake in GSA 17, 18	1.68	N	-	-
FAO37	Central Med.	2021	hke_19	European hake in GSA 19	1.59	N	-	-
FAO37	Central Med.	2021	hke_20	European hake in GSA 20	2.13	N	-	-
FAO37	Central Med.	2020	mts_17	Spottail mantis squillid in GSA 17	0.80	Y	-	-
FAO37	Central Med.	2021	mur_15_16	Striped Red Mullet (Surmullet) in GSA 15, 16	1.25	N	-	-
FAO37	Central Med.	2020	mut_15	Red mullet in GSA 15	1.60	N	-	-
FAO37	Central Med.	2020	mut_16	Red mullet in GSA 16	0.39	Y	-	-
FAO37	Central Med.	2020	mut_17_18	Red mullet in GSA 17, 18	1.05	N	-	-
FAO37	Central Med.	2021	mut_19	Red mullet in GSA 19	0.61	Y	-	-
FAO37	Central Med.	2020	mut_20	Red mullet in GSA 20	1.10	N	-	-
FAO37	Central Med.	2021	nep_15_16	Norway lobster in GSA 15, 16	2.00	N	-	-
FAO37	Central Med.	2021	nep_17_18	Norway lobster in GSA 17, 18	0.40	Y	-	-
FAO37	Central Med.	2020	pil_16	European pilchard(=Sardine) in GSA 16	2.78	N	-	-
FAO37	Central Med.	2019	pil_17_18	European pilchard(=Sardine) in GSA 17, 18	4.49	N	-	-
FAO37	Central Med.	2021	sol_17	Common sole in GSA 17	0.76	Y	-	-
FAO37	Eastern Med.	2021	hke_22	European hake in GSA 22	4.77	N	-	-
FAO37	Eastern Med.	2021	mut_22	Red mullet in GSA 22	0.70	Y	-	-

Region	EcoRegion	Year	Stock	Description	F ind	F status	SBL	CFP
FAO37	Eastern Med.	2019	mut_25	Red mullet in GSA 25	1.44	N	-	-
FAO37	Eastern Med.	2020	sba_25	Axillary seabream in GSA 25	1.05	N	-	-
FAO37	Western Med.	2020	ane_7	European anchovy in GSA 7	0.05	Y	-	-
FAO37	Western Med.	2020	ane_9	European anchovy in GSA 9	0.35	Y	-	-
FAO37	Western Med.	2021	ara_1_2	Blue and red shrimp in GSA 1, 2	4.08	N	-	-
FAO37	Western Med.	2021	ara_5	Blue and red shrimp in GSA 5	4.81	N	-	-
FAO37	Western Med.	2021	ara_6_7	Blue and red shrimp in GSA 6, 7	3.25	N	-	-
FAO37	Western Med.	2020	ara_9_10_11	Blue and red shrimp in GSA 9, 10, 11	4.60	N	-	-
FAO37	Western Med.	2021	ars_9_10_11	Giant red shrimp in GSA 9, 10, 11	1.78	N	-	-
FAO37	Western Med.	2021	dps_1	Deep-water rose shrimp in GSA 1	0.87	Y	-	-
FAO37	Western Med.	2021	dps_5_6_7	Deep-water rose shrimp in GSA 5, 6, 7	0.44	Y	-	-
FAO37	Western Med.	2021	dps_8_9_10_11	Deep-water rose shrimp in GSA 8, 9, 10, 11	1.11	N	-	-
FAO37	Western Med.	2021	hke_1_5_6_7	European hake in GSA 1, 5, 6, 7	3.26	N	-	-
FAO37	Western Med.	2021	hke_8_9_10_11	European hake in GSA 8, 9, 10, 11	3.60	N	-	-
FAO37	Western Med.	2020	mur_5	Striped Red Mullet (Surmullet) in GSA 5	1.96	N	-	-
FAO37	Western Med.	2021	mut_1	Red mullet in GSA 1	2.33	N	-	-
FAO37	Western Med.	2020	mut_10	Red mullet in GSA 10	0.78	Y	-	-
FAO37	Western Med.	2021	mut_6	Red mullet in GSA 6	3.41	N	-	-
FAO37	Western Med.	2021	mut_7	Red mullet in GSA 7	1.02	N	-	-
FAO37	Western Med.	2021	mut_9	Red mullet in GSA 9	1.09	N	-	-
FAO37	Western Med.	2020	nep_5	Norway lobster in GSA 5	0.69	Y	-	-
FAO37	Western Med.	2021	nep_6	Norway lobster in GSA 6	2.95	N	-	-
FAO37	Western Med.	2021	nep_9	Norway lobster in GSA 9	1.53	N	-	-
FAO37	Western Med.	2019	pil_1	European pilchard(=Sardine) in GSA 1	4.34	N	-	-
FAO37	Western Med.	2020	pil_6	European pilchard(=Sardine) in GSA 6	1.72	N	-	-
FAO37	Western Med.	2020	pil_7	European pilchard(=Sardine) in GSA 7	-	-	-	-
FAO37	Western Med.	2020	pil_9	European pilchard(=Sardine) in GSA 9	0.19	Y	-	-
FAO37	Western Med.	2020	sbr_1_3	Blackspot(=red) seabream in GSA 1, 3	0.77	Y	-	-

7 HISTORICAL TRENDS

As the number of stocks under consideration changes every year due to the availability of stock assessments, historical retrospectives of both modelled indicators (F/F_{MSY} and B/B_{2003}) were carried out (Figure 28-Figure 31). The indicators were grouped by FAO region. The input data were the F and B modelled indicators computed each year for the purpose of monitoring the CFP performance since 2017. The time horizon was 6 years, this means up to 6 years of data were peeled off before estimating the indicators. Only the median was used to compare inter-annual behaviour.

In the Northeast Atlantic, the trajectories of both F/F_{MSY} and B/B_{2003} were generally consistent over the years they were computed.

The fishing pressure exhibited a decreasing trend over the period 2003-2021 (Figure 28). The results obtained by the CFP monitoring for the F/F_{MSY} indicators computed from 2017 to 2021 showed a regular upward revision of the time series. That pattern seems to have changed over the last two years (CFP monitoring 2022 and 2023).

The biomass indicator exhibited an increasing trend over the period 2003-2021. A downward revision pattern of the indicator seems to be displayed in Figure 29 although it appears less obvious than in the fishing pressure indicator.

In the Mediterranean and Black Seas, the fishing pressure indicator F/F_{MSY} (Figure 30) does not show a pattern as clear as in the Northeast Atlantic equivalent. However, over the last 3 years (CFP monitorings 2021 to 2023), a downward revision of the time series was observed. It should be noted that the number of stocks included in the analysis in 2023 has significantly increased compared to the previous analysis (57 vs 34).

The retrospective of the biomass indicator (B/B_{2003}) does not show any obvious patterns since 2017 (Figure 31). However, the indicator shows an important instability from year to year. As for the fishing pressure indicator, it should be noted that the number of stocks considered in this report (58) has significantly increased compared to last year's report (34).

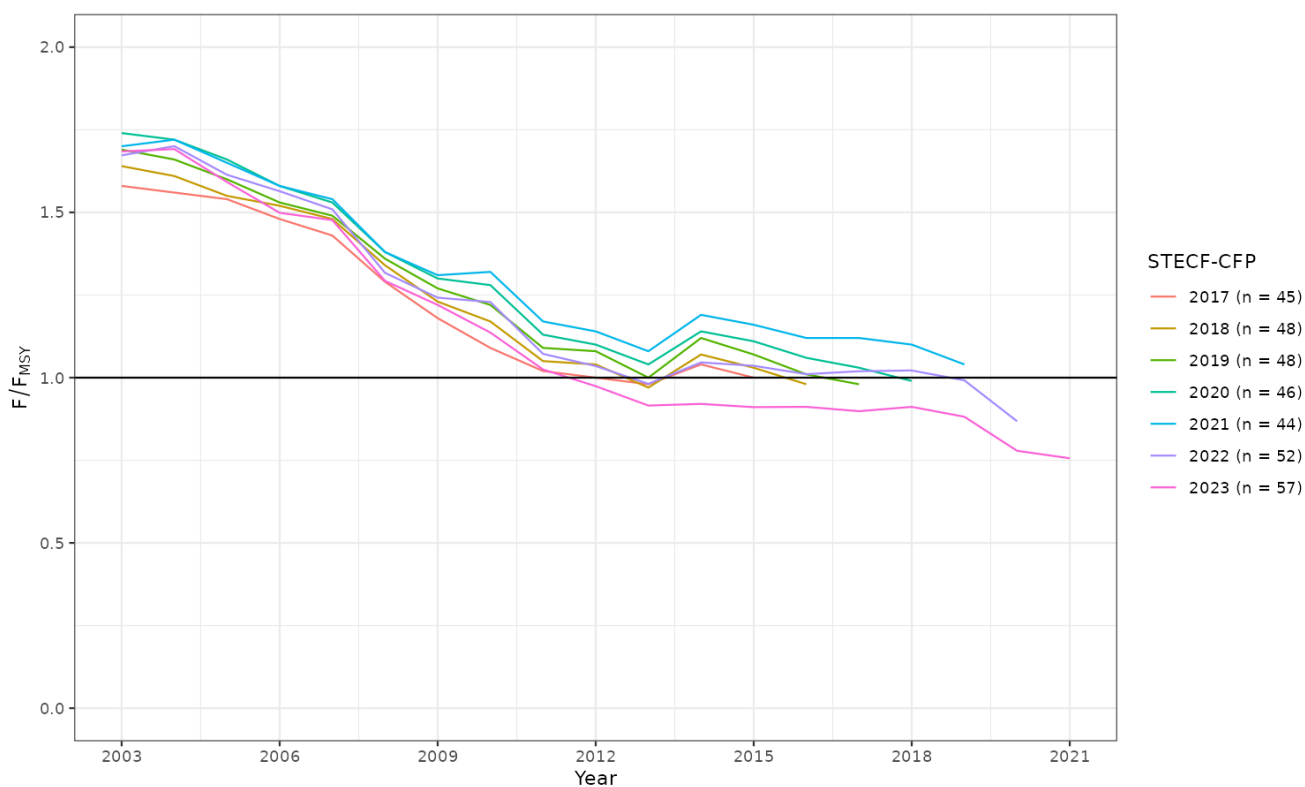


Figure 28: Historical retrospective reported in STECF CFP monitoring reports since 2017 for F/F_{MSY} in the Northeast Atlantic Area

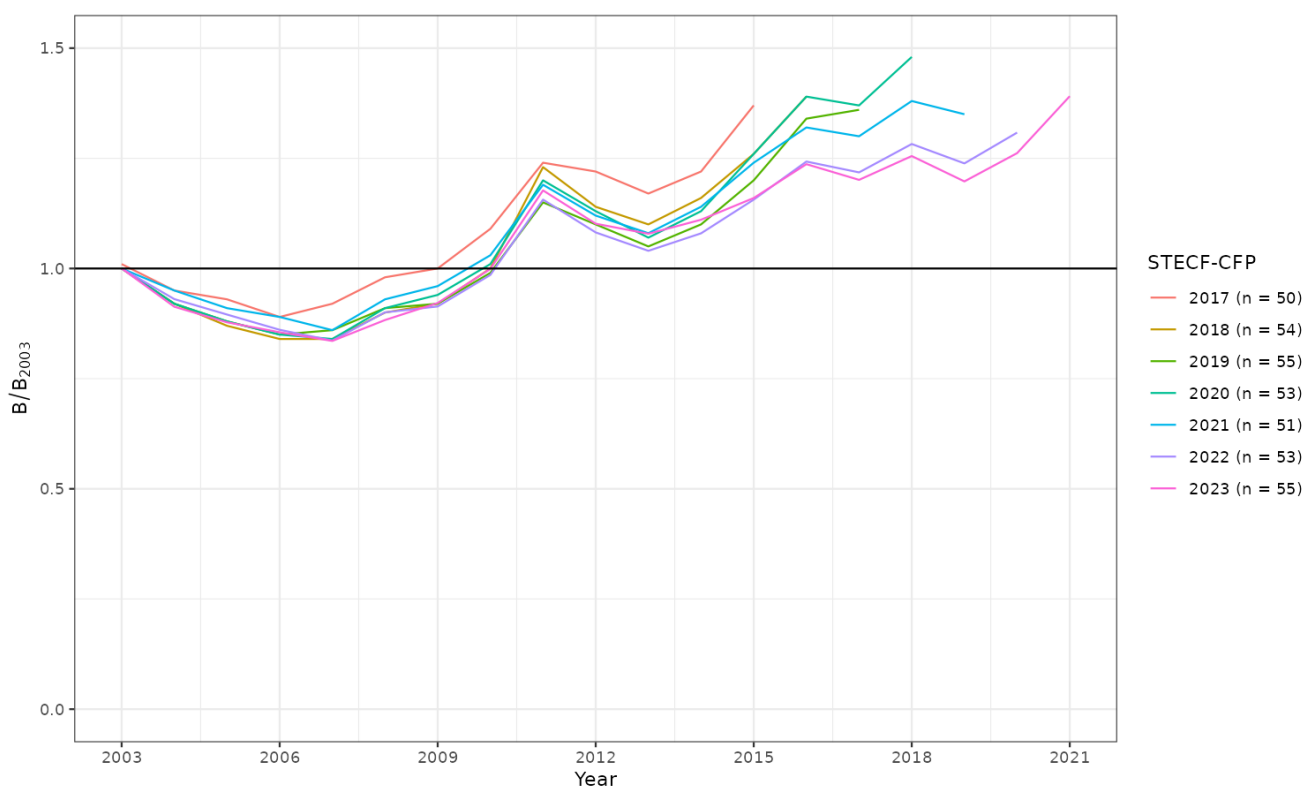


Figure 29: Historical retrospective reported in STECF CFP monitoring reports since 2017 for B/B_{2003} in the Northeast Atlantic Area

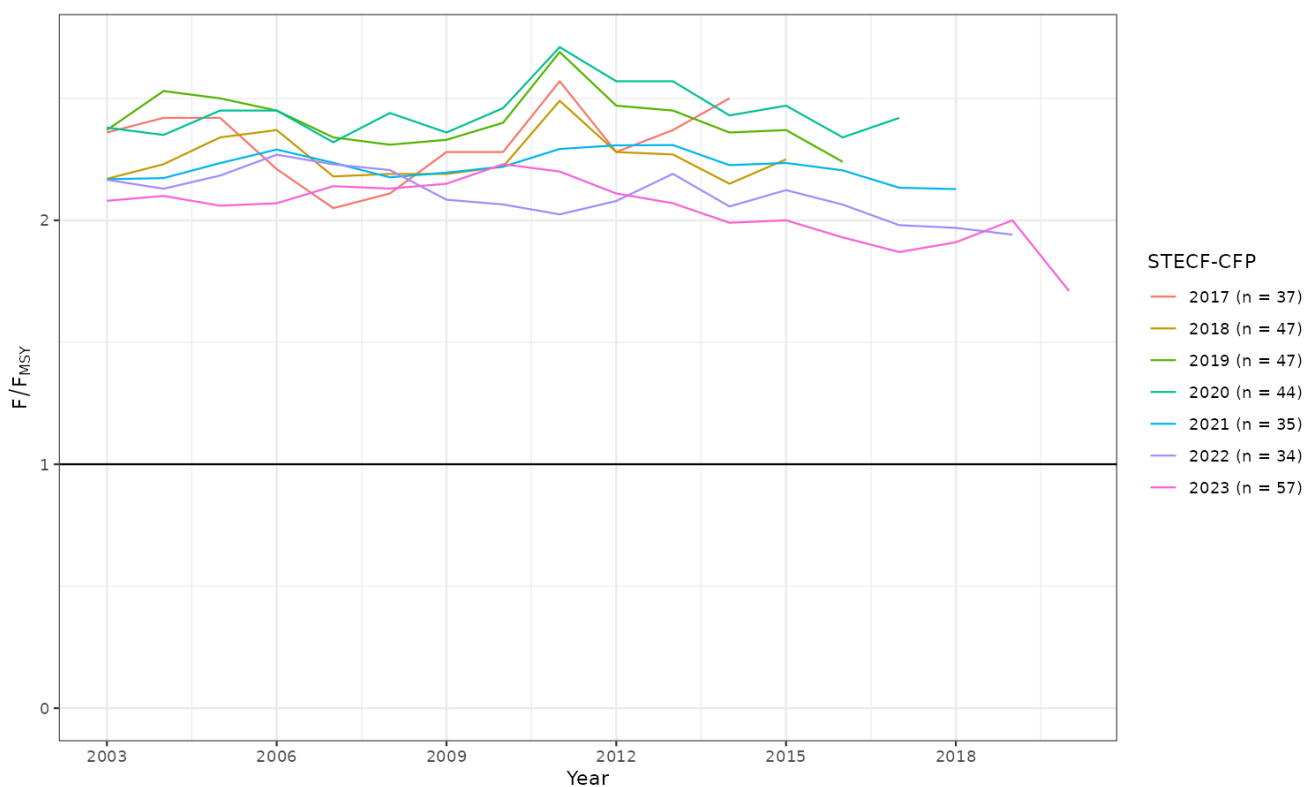


Figure 30: Historical retrospective reported in STECF CFP monitoring reports since 2017 for F/F_{MSY} in the Mediterranean and Black Seas Area

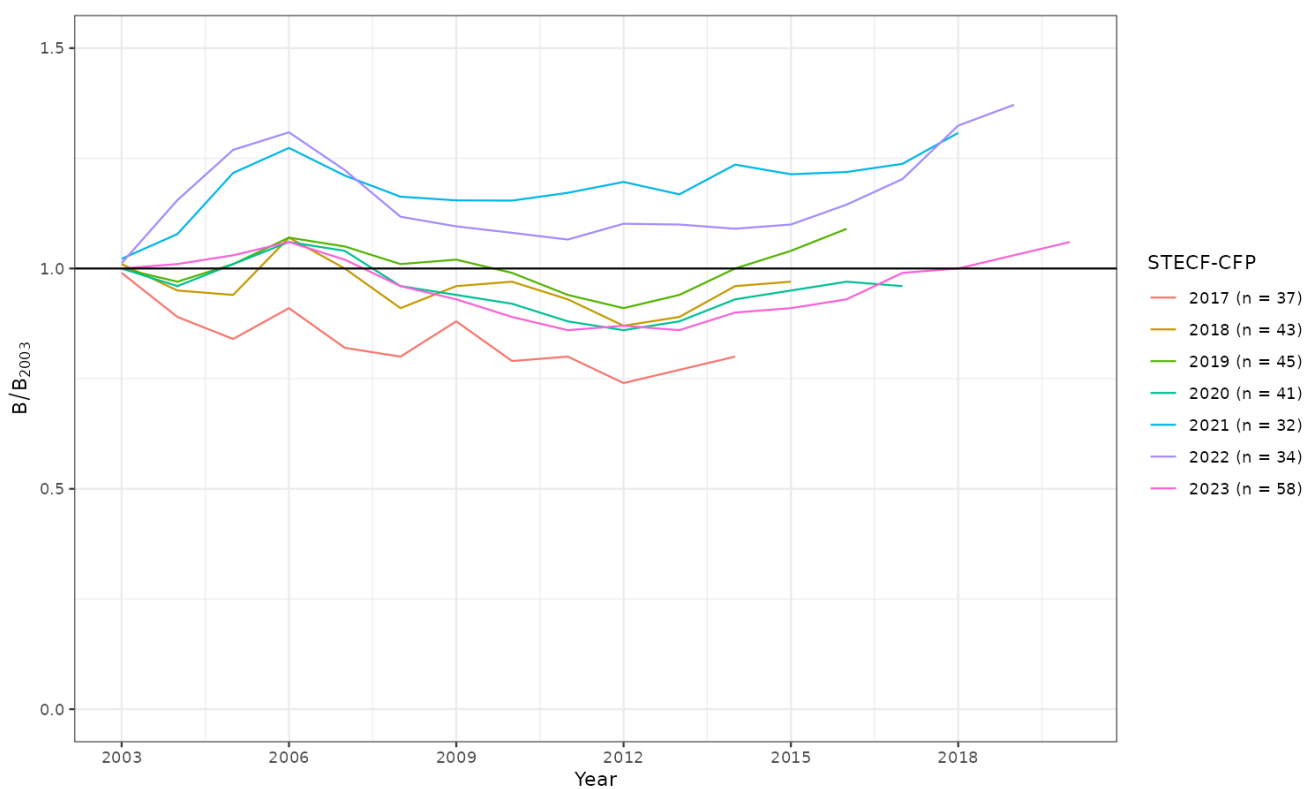


Figure 31: Historical retrospective reported in STECF CFP monitoring reports since 2017 for B/B_{2003} in the Mediterranean and Black Seas Area

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9 CONTACT DETAILS OF EWG-23-ADHOC-01 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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10 LIST OF ANNEXES

Electronic annexes are published on the meeting's web site on:
<https://stecf.jrc.ec.europa.eu/reports/cfp-monitoring>

List of electronic annexes documents:

EWG-adhoc-23-01 – Annex 1 – URL Links to the source of the reports by stock

EWG-adhoc-23-01 – Annex 2 – ICES data quality issues corrected prior to the analysis

EWG-adhoc-23-01 – Annex 3 – R code for computing all European waters indicators

11 LIST OF BACKGROUND DOCUMENTS

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

List of background documents:

EWG-23-adhoc-01 – Doc 1 - Declarations of JRC experts (see also section of this report – List of participants)

Protocol for the Monitoring of the Common Fisheries Policy

Version 4.0

January 31, 2019

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1 Introduction

The monitoring of the Common Fisheries Policy (CFP, Reg (EU) 1380/2013) implementation is of utmost importance for the European Union (EU), European Commission (EC) and its Directorate-General for Maritime Affairs and Fisheries (DG MARE).

The European Commission Scientific, Technical and Economic Committee for Fisheries (STECF), as the major scientific advisory body on fisheries policy to the EC, has the task of reporting on the CFP implementation through the estimation and publication of a series of indicators.

To make the process as consistent as possible, the following set of rules were developed to be used as a guiding protocol for computing the required indicators. The rules also contribute to the transparency of the process.

The protocol covers the three major elements in the process:

- Data issues: data sources, reference list of stocks, selection of stocks, etc;
- Indicators of management performance: description of the indicators, procedures for their computation and presentation format;
- Indicators of changes in advice coverage: description of the indicators, procedures for their computation and presentation format.

1.1 Scope

The monitoring of the CFP should cover all areas where fleets operate under the flag of any EU member state. However, due to limitations on data and the mitigated responsibility of the EU on management decisions on waters outside the EU EEZ (Exclusive Economic Zone), the analysis will mainly focus on stocks within the EU EEZ in the FAO areas 27 (NEA: Northeast Atlantic and Adjacent Seas) and 37 (MED: Mediterranean and Black Sea).

The analysis will have two perspectives, at the global EU level and a regional overview where the indicators are computed for the following regions, if enough data is available:

- Baltic Sea (NEA)
- Greater North Sea (NEA)
- Celtic Sea (NEA)
- Bay of Biscay and Iberian Waters (NEA)
- Widely distributed stocks (NEA)
- Western Mediterranean (MED)
- Eastern Mediterranean (MED)
- Central Mediterranean (MED)
- Black Sea (MED)

1.2 Definitions

- f or F represent fishing mortality;
- b or B represent biomass, either as total stock biomass or spawning stock biomass (SSB);
- k represents a standardized biomass index, which is considered by experts to represent the evolution of biomass over time;
- r represents recruitment (young individuals entering the fishery) in number of individuals;

- F_{MSY} represents fishing mortality that produces catches at the level of MSY in an equilibrium situation, or a proxy;
- F_{PA} is the precautionary reference point for fishing mortality;
- B_{MSY} is the biomass expected to produce MSY when fished at F_{MSY} in an equilibrium situation, but also any other relevant proxy considered by the scientific advice body;
- B_{PA} is the precautionary reference point for spawning stock biomass;
- indices:
 - $j = 1 \dots N$ indexes stocks, where N is the total number of stocks selected for the analysis;
 - $t = 1 \dots T$ indexes years, where T is the number of years in the reported time series;
 - $m = 1 \dots M$ indexes sampling units, where M is the total number of stocks in the reference list;
 - $s = 1 \dots S$ indexes bootstrap simulations;
- operations:
 - \vee stands for *or* in Boolean logic;
 - \wedge stands for *and* in Boolean logic;
- model parameters:
 - u is a random effect in stock;
 - y is a fixed effect in year.

2 Data

2.1 Data sources

All indicators are computed using results from single species quantitative stock assessments. Time series of estimates of fishing mortality, spawning stock biomass, and the adopted biological reference points for each stock are to be provided by the International Council for the Exploration of the Sea (ICES), the General Fisheries Commission for the Mediterranean (GFCM) and STECF.

Results from surplus production models and delay-difference models, which are mostly reported as ratios between F and F_{MSY} and/or B over B_{MSY} , are also included in the analysis.

Results from pseudo-cohort analysis and similar methods are not included. These models do not estimate time series of fishing mortality or spawning stock biomass.

Results from methods that directly estimate total abundance and/or harvest rate may be used for the computation of some indicators.

2.2 Reference list of stocks

The list of stocks to be used for computing indicators, hereafter termed the *reference list*, is used to stabilize the basis on which the indicators are computed. It assures that the relevant stocks are considered and constitutes the base for computing the scientific coverage of the advice. The reference list must include at least those stocks that are subject to direct management from the EU, as changes in their status can be linked more clearly to the implementation of the CFP.

Because of the differences in the nature and availability of data and information in different regions, region-specific reference lists were adopted for the EU waters:

- Northeast Atlantic (FAO area 27): The list of stocks comprises all stocks subject to management by Total Allowable Catch (TAC) limits.

- Mediterranean and Black Sea (FAO area 37): the list of stocks comprises all stocks of the species
 - anchovy (*Engraulis encrasicolus*)
 - blackbellied angler (*Lophius budegassa*)
 - blue and red shrimp (*Aristeus antennatus*)
 - giant red shrimp (*Aristaeomorpha foliacea*)
 - deep-water rose shrimp (*Parapenaeus longirostris*)
 - hake (*Merluccius merluccius*)
 - striped red mullet (*Mullus surmuletus*)
 - red mullet (*Mullus barbatus*)
 - Norway lobster (*Nephrops norvegicus*)
 - sardine (*Sardina pilchardus*)
 - common sole (*Solea solea*)
 - sprat (*Sprattus sprattus*)
 - turbot (*Psetta maxima*)
 - blue whiting (*Micromesistius poutassou*)
 - whiting (*Merlangius merlangus*)

plus the stocks ranked in the top ten in either landings or reported economic value over the 2012-2014 period.

2.3 Selection of stock assessments

- The stock assessments to be selected include all stock assessments carried out in the three years before the analysis, are listed in the reference list and have at least 5 years of estimates.
- Exploratory assessments or assessments not yet approved by the advisory bodies are not considered;
- When several stocks are merged in a single stock only the aggregated stock is considered, the reference list must be updated accordingly;
- When a stock is split in two (or more) stocks only the disaggregated stocks are considered, the reference list must be updated accordingly;
- If two assessments for the same stock exist the most recent one is kept.
- if two assessments in the same year for the same stock exist the one from the relevant RFMO is kept.

Selected stocks of which the stock assessment results don't cover the recent period of evaluation, the most recent estimates available will be kept constant and replicated up to the most recent year of the analysis.

3 Indicators of management performance

The indicators employed to monitor the performance of the CFP management regime reflect the evolution of exploitation status and conservation status.

The first group of indicators build a historical perspective by simply counting the number of stocks above/below a defined threshold in each year. A second group of indicators model a trend over time with a Generalized Linear Mixed Model (GLMM), using *stock* as a random effect, *year* as a fixed effect, and a Gamma distribution with a *log* link. The indicator is the model prediction of the *year* effect, and the indicator's uncertainty is computed with a block bootstrap procedure using *stock* as blocks. This model was tested in a simulation study¹ and in an application to Mediterranean stocks².

¹Minto, C. 2015. Testing model based indicators for monitoring the CFP performance. Ad-hoc contract report, pp 14.

²Chato-Osio, G., Jardim, E., Minto, C., Scott, F. and Patterson, K. 2015. Model based CFP indicators, F/F_{MSY} and SSB. Mediterranean region case study. JRC Technical Report No XX, pp 26.

3.1 Number of stocks where fishing mortality exceeds F_{MSY}

$$I_t = \sum_{j=1}^{j=N} (f_{jt} > F_{MSY})$$

3.2 Number of stocks where fishing mortality is equal to or less than F_{MSY}

$$I_t = \sum_{j=1}^{j=N} (f_{jt} \leq F_{MSY})$$

3.3 Number of stocks outside safe biological limits

$$I_t = \sum_{j=1}^{j=N} (f_{jt} > F_{PA} \vee b_{jt} < B_{PA})$$

3.4 Number of stocks inside safe biological limits

$$I_t = \sum_{j=1}^{j=N} (f_{jt} \leq F_{PA} \wedge b_{jt} \geq B_{PA})$$

3.5 Number of stocks where F is above F_{MSY} or SSB is below B_{MSY}

$$I_t = \sum_{j=1}^{j=N} (f_{jt} > F_{MSY} \vee b_{jt} < B_{MSY})$$

where in FAO 27

$$B_{MSY} = MSY B_{trigger}$$

3.6 Number of stocks where F is below or equal to F_{MSY} and SSB is above or equal to B_{MSY}

$$I_t = \sum_{j=1}^{j=N} (f_{jt} \leq F_{MSY} \wedge b_{jt} \geq B_{MSY})$$

where in FAO 27

$$B_{MSY} = MSY B_{trigger}$$

3.7 Trend in F/F_{MSY}

For these indicators stocks managed under escapement strategies and stocks for which fishing mortality was reported as a harvest rate are not included.

$$I_t = y_t$$

$$z_{jt} = \beta_0 + y_t + u_j$$

where

$$z_{jt} = \log E\left[\frac{f_{jt}}{F_{MSY}}\right]$$

and

$$\frac{f_{jt}}{F_{MSY}} \sim \text{Gamma}(\alpha, \beta)$$

3.8 Trend in *SSB*

For this indicator stocks for which biomass was reported as a relative value or total abundance are not included. This indicator is scaled to the 2003 estimate for presentational purposes.

$$I_t = \text{median}(\exp(\log y_{ts} - S^{-1} \sum_{s=1}^{s=S} \log y_{2003,s}))$$

$$z_{jt} = \beta_0 + y_t + u_j$$

where

$$z_{jt} = \log E[b_{jt}]$$

and

$$b_{jt} \sim \text{Gamma}(\alpha, \beta)$$

3.9 Trend in recruitment

The indicator is computed using the ratio between the average decadal recruitment of two following decades. For each year the previous decade and the decade before are used. The time window moves with years as such building the time series used for the indicator.

$$I_t = y_t$$

$$z_{jt} = \beta_0 + y_t + u_j$$

where

$$z_{jt} = \log E[d_{jt}]$$

and

$$d_{jt} = \frac{\sum_{t=1}^{t=-10} r_{jt}}{\sum_{t=-11}^{t=-20} r_{jt}}$$

and

$$d_{jt} \sim \text{Gamma}(\alpha, \beta)$$

3.10 Trend in biomass for data limited stocks

This indicator uses biomass indices computed from scientific surveys or CPUE (catch per unit of effort) considered by experts to represent the evolution of biomass in time. The data is build from the list of biomass indices published by ICES for data limited stocks category 3.

The indicator is calculated on a model-based form only,

$$I_t = y_t$$

$$z_{jt} = \beta_0 + y_t + u_j$$

where

$$z_{jt} = \log E[k_{jt}]$$

and

$$k_{jt} \sim \text{Gamma}(\alpha, \beta)$$

4 Indicators of changes in advice coverage

These indicators are computed for the last year of the analysis only.

4.1 Number of stocks for which estimates of F_{MSY} exist

$$I = \sum_{j=1}^{j=N} (x_j = \lambda)$$

$$\lambda = \begin{cases} x = 1 & F_{MSY} \text{ exists} \\ x = 0 & \text{otherwise} \end{cases}$$

4.2 Number of stocks for which estimates of B_{PA} exist

$$I = \sum_{j=1}^{j=N} (x_j = \lambda)$$

$$\lambda = \begin{cases} x = 1 & B_{PA} \text{ exists} \\ x = 0 & \text{otherwise} \end{cases}$$

4.3 Number of stocks for which estimates of B_{MSY} exist

$$I = \sum_{j=1}^{j=N} (x_j = \lambda)$$

$$\lambda = \begin{cases} x = 1 & B_{MSY} \text{ exists} \\ x = 0 & \text{otherwise} \end{cases}$$

4.4 Fraction of TACs covered by stock assessments

This indicator considers that a sampling frame unit is covered by a stock assessment if there is at least a partial overlap between its spatial distribution and the spatial distribution of the stock.

$$I = M^{-1} \sum_{m=1}^{m=M} (x_m = \lambda)$$
$$\lambda = \begin{cases} x = 1 & \text{spatial overlap exists} \\ x = 0 & \text{otherwise} \end{cases}$$

5 Transparency

Changes or additions to this protocol shall be approved by STECF.

To promote transparency of scientific advice and allow the public in general, and stakeholders in particular, to have access to the data and analysis carried out, all code and data part of this analysis must be published online once approved by the STECF plenary.

13 ANNEX 2 – NORTHEAST ATLANTIC CODE

```
#####  
#####  
##      ##  
## Michael Gras (2023-01) ##  
## NEA indicators      ##  
##      ##  
#####  
#####  
  
#####  
# Libraries #  
#####  
  
library(ggplot2)  
library(lattice)  
library(lme4)  
library(influence.ME)  
library(parallel)  
library(rgdal)  
library(plyr)  
library(reshape2)  
library(data.table)  
library(JARA)  
  
#####  
# Working directory #  
#####  
  
rm(list=ls())  
gc()  
setwd("~/gitlab/2023-cfpindicators/")  
  
# Functions required to run the analysis with the GLMM  
source("NEA/script/funs.R")  
  
# Functions required to run the analysis with JARA  
# source("NEA/script/jara_func.R")  
  
#####  
# Variables #  
#####  
  
# year when assessments were performed  
assessmentYear <- 2022  
  
# final data year with estimations from stock assessments  
fnlYear <- assessmentYear - 1  
  
# initial data year with estimations from stock assessments  
iniYear <- 2003  
  
# vector of years  
dy <- iniYear:fnlYear  
  
# vector of years for valid assessments
```

```

vay <- (assessmentYear-2):assessmentYear

# vector of years for stock status projection
vpy <- (fnyYear-2):fnyYear

# options for reading data
options(stringsAsFactors=FALSE)

# number of simulations for mle bootstrap
it <- 1000

# number of cores for mle bootstrap parallel
nc <- 11 #(11 on Michael's laptop and 150 on SNES)

# quantiles to be computed
qtl <- c(0.025, 0.25, 0.50, 0.75, 0.975)

# to control the seed in mclapply
RNGkind("L'Ecuyer-CMRG")
set.seed(1234)

# to make plots consistent
vp <- dy
vp[c(2,3,5,6,8,9,11,12,14,15)] <- ""
theme_set(theme_bw())
sc <- scale_x_continuous(breaks=seq(iniYear, fnyYear, 2)) #, labels=as.character(vp)
th <- theme(axis.text.x = element_text(angle=90, vjust=0.5), panel.grid.minor =
element_blank())

# To save csv files, RData files and graphs turn the following to true
savecsv <- FALSE
savedata <- FALSE
savegraph <- FALSE
fitit <- FALSE
bootstrap <- FALSE
rundiags <- FALSE

# set minimum observation error (CV=5%) to avoid overfitted through process error (used
for JARA)
obsmin <- 0.05

isa <- Data

# order by year
isa <- isa[order(isa$Year),]

# reporting stk by data category
stBydc <- unique(subset(isa, Year %in% vpy)[,c("FishStock", "DataCategory",
"EcoRegion")])
stBydc <- transform(stBydc, cat=as.integer(DataCategory))
if (savecsv) write.csv(table(stBydc[,c("EcoRegion", "cat")]), file="NEA/results/stBydc.csv")

# check thoroughly this table before moving on to the next analysis

#-----
# ICES rectangles data
#-----

# Import shapefile of ICES rectangles into R

```

```

rectangles      <-      readOGR("NEA/data/ices_areas",      layer=
"ICES_StatRec_map_Areas_Full_20170124")

# Extract only the table containing ICES subdivisions names for FAO 27 and rename
columns
rectangles <- rectangles@data[,c("Area_27", "AreasList", "ICESNAME")]
colnames(rectangles) <- c("Max_Area", "Area_List", "Rectangle")
rectangles <- subset(rectangles, !is.na(Max_Area))

# A new column is added based on Max_Area so that it is comparable across the other
data sets.
# Paste "27." to have some standard formats
rectangles$Area <- paste("27.", toupper(as.character(rectangles$Max_Area)), sep="")

# Check that each rectangle is unique and only appears once in the data
# i.e. each rectangle is uniquely assigned to one area the output should be TRUE
length(unique(rectangles$Rectangle)) == nrow(rectangles)
#TRUE

#-----
# sampling frame (TACs)
#-----

# Load an RData file containing
# norwg seems to be Norwegian stock information
# specond seems to be information by species about TAC_id and linked area
# sal seems to be salmon id
# sframe_TAC looks like TAC id (used in the script)
# nogrp seems to be TAC id that are irrelevant for the CFP monitoring
# scs
# fmz (used in the script)
# stockdef

load("NEA/data/sframe.RData", verbose=T)

# Not all the objects from sframe.RData
rm(norwg, specond, sal, nogrp, scs, stockdef)
# fmz is the frame of all TACs
# For consistency, rename area -> Area, ssp -> Species, stock_id -> TAC_id
colnames(fmz) <- c("fmz_id", "f_level", "TAC_id", "Area", "f_area", "f_subarea",
"f_division", "f_subdivis", "f_subunit", "ices_area", "Species", "fmz")

# Filter only the stocks that are in sframe_TAC which are the ones concerned by this
analysis, the other ones are filtered out.
sframe <- fmz[fmz$TAC_id %in% sframe_TAC,]

# Each ICES area should only appear once for each FMZ stock (to prevent the appearance
of duplicate rectangles when merging with the ICES rectangle data later). We check this
here:

unarea <- dapply(sframe, .(TAC_id), function(x){
  return(length(unique(x$Area))==nrow(x))
})
all(unarea)

#-----
# subset assessments and ecoregions, add areas
#-----

```



```

# keep only cat 1 & 2 and keep only specific columns
isa12 <- isa[isa$DataCategory<3, c("FishStock","ICES.Areas..splited.with.character....." ,
"SpeciesName", "SGName", "DataCategory", "EcoRegion")]
colnames(isa12) <- c("FishStock", "Areas", "SpeciesName", "SGName", "DataCategory",
"EcoRegion")

# Drop duplicates
isa12 <- unique(isa12)

# Remove white space and any capital letters from assessment name
isa12[, "FishStock"] <- tolower(gsub("\\s", "", isa12[, "FishStock"]))
isa12[isa12$FishStock=="her.27.6an", "FishStock"] <- "her.27.6aN"
isa12[isa12$FishStock=="her.27.6as7bc", "FishStock"] <- "her.27.6aS7bc"

# Make a species column from the assessment name
spp <- strsplit(isa12[, "FishStock"], "\\.")
isa12$Species <- toupper(unlist(lapply(spp, function(x) x[1])))

# Split ICES area by ~
areas <- strsplit(isa12[, "Areas"], "~")
names(areas) <- isa12[, "FishStock"]
areas <- reshape2::melt(areas)
colnames(areas) <- c("Area", "FishStock")
isa12 <- merge(isa12, areas)

# keep relevant columns only
isa12 <- isa12[, c("FishStock", "Area", "Species", "SpeciesName", "SGName",
"DataCategory", "EcoRegion")]
isa12[, "Area"] <- toupper(gsub("\\s", "", isa12[, "Area"]))

# remove ecoregions outside EU waters
#isa12 <- subset(isa12, !(EcoRegion %in% c("Arctic Ocean", "Greenland Sea", "Faroes",
"Iceland Sea")))
isa12 <- subset(isa12, !(EcoRegion %in% c("Arctic Ocean", "Iceland, Greenland and
Faroes")))

# drop if ecoregion is NA
isa12 <- subset(isa12, !is.na(EcoRegion))

# remove her-noss which is widely distributed but mainly norway; 2022: We keep it that
way
isa12 <- subset(isa12, FishStock!="her.27.1-24a514a")

#List of stocks to check,
#isa12[isa12$FishStock=="ank.27.8c9a",] # upgrade from cat 3 to cat 2 SPiCT; 1980-
2021; relative ref points; B relative to Bmsy and F relative to Fmsy; No Recruitment
estimate
#isa12[isa12$FishStock=="aru.27.5a14",] # considered outside EU
#isa12[isa12$FishStock=="aru.27.5b6a",] # considered outside EU
#isa12[isa12$FishStock=="cod.27.1-2.coastn",] # considered outside EU
#isa12[isa12$FishStock=="her.27.3031",] # Baltic upgrade from cat 5 to cat 1 SS3; 1963-
2021; Ref Pts from management plan
#isa12[isa12$FishStock=="lez.27.6b",] # upgrade from cat 3 to cat 2 SPiCT; relative ref
points; B relative to Bmsy and F relative to Fmsy; No Recruitment estimate
#isa12[isa12$FishStock=="lin.27.5b",] # considered outside EU
#isa12[isa12$FishStock=="nep.fu.25",] # upgrade from cat 3 to cat 2 SPiCT ; relative ref
points; B relative to Bmsy and F relative to Fmsy; No Recruitment estimate

```

```
#isa12[isa12$FishStock=="nep.fu.2627",] # upgrade from cat 3 trend in CPUE to cat 2
SPiCT; 1975-2021; relative ref points; B relative to Bmsy and F relative to Fmsy; No
Recruitment estimate
#isa12[isa12$FishStock=="nep.fu.31",] # upgrade from cat 3 trend in CPUE to cat 2
SPiCT; 1987-2021; relative ref points; B relative to Bmsy and F relative to Fmsy; No
Recruitment estimate
#isa12[isa12$FishStock=="sol.27.7d",] # upgrade from cat 3 XSA Cat 1 SAM assessment
1982-2021 Management plan in place
#isa12[isa12$FishStock=="whg.27.6a",] # upgrade from cat 5 to cat 1 SAM assessment
1981-2021
```

```
#-----
# fix area codes
#-----
```

```
# fix Baltic area codes
rectangles[rectangles$Area == "27.3.A.20","Area"] <- "27.3.A"
rectangles[rectangles$Area == "27.3.A.21","Area"] <- "27.3.A"
rectangles[rectangles$Area == "27.3.B.23","Area"] <- "27.3.B"
rectangles[rectangles$Area == "27.3.C.22","Area"] <- "27.3.C"
```

```
isa12[isa12$Area == "27.3.A.20","Area"] <- "27.3.A"
isa12[isa12$Area == "27.3.A.21","Area"] <- "27.3.A"
isa12[isa12$Area == "27.3.B.23","Area"] <- "27.3.B"
isa12[isa12$Area == "27.3.C.22","Area"] <- "27.3.C"
```

```
sframe[sframe$Area == "27.3.20","Area"] <- "27.3.A"
sframe[sframe$Area == "27.3.21","Area"] <- "27.3.A"
sframe[sframe$Area == "27.3.23","Area"] <- "27.3.B"
sframe[sframe$Area == "27.3.22","Area"] <- "27.3.C"
```

```
# Check: shouldn't have any 24.x.x areas
# Areas in ICES assessment but missing in rectangles
### rewrite
unique(isa12$Area)[!(unique(isa12$Area) %in% unique(rectangles$Area))]
#NA
```

```
# Areas in FMZ but missing in rectangles
unique(sframe$Area)[!(unique(sframe$Area) %in% unique(rectangles$Area))]
#[1] "21.1.F" "21.3.M" "34.1.2" "34.1.13" "34.1.11" "34.1.12" "34.2"
```

```
#-----
# fix species codes
#-----
```

```
#check the species code
# Horse mackerel
# Checked in 2022 and HOM still exists
isa12[isa12$Species=="HOM","Species"] <- "JAX"
# ANK & MON - Anglerfish - species to genus
# Checked in 2022 and MON still exist. In 2022 ANK still exists (it was commented last
year)
isa12[isa12$Species=="ANK","Species"] <- "ANF"
isa12[isa12$Species=="MON","Species"] <- "ANF"
# Megrim - species and genus to genus
# Checked in 2022 and MEG+LDB still exist
isa12[isa12$Species=="MEG","Species"] <- "LEZ"
isa12[isa12$Species=="LDB","Species"] <- "LEZ"
# species with combined TACs (NOTE THESE CAN INCREASE IN THE FUTURE)
```

```

# WIT there's a combined TAC with lemon sole: L/W/2AC4-C
# TUR there's a combined TAC with brill T/B/2AC4-C
# Both TUR and WIT were not cat 1 in 2017 assessments
isa12[isa12$Species=="WIT","Species"] <- "L/W"
isa12[isa12$Species=="TUR","Species"] <- "T/B"
# missing species
sort(unique(isa12$Species)[!(unique(isa12$Species) %in% unique(sframe$Species))])
#[1] "BSS" "PIL"
# PIL and BSS don't have TACs
#TUR and WIT are now coded as combined TACs stocks

#-----
# merge assessments,tacs/sf and rectangles
#-----

# merge assessments with rectangles
isa12r <- merge(isa12, rectangles[,c("Area","Rectangle")], by="Area")

# Do we have all the assessments?
all(sort(unique(isa12$FishStock)) == sort(unique(isa12r$FishStock)))

# Merge sampling frame with rectangles
sfr <- merge(sframe, rectangles[,c("Area","Rectangle")], by="Area")

# Do we have all the TACs?
all(sort(unique(sframe$TAC_id)) == sort(unique(sfr$TAC_id)))

# merge assessments with sampling frame
isa12sf <- merge(sfr, isa12r[,c("Species","Rectangle","FishStock","DataCategory")],
by=c("Species","Rectangle"), all.x = TRUE)

# At this stage we kept 78 stocks out of 109 in the 2022 exercise
# At this stage we kept 81 stocks out of 123 in the 2023 exercise

#-----
# final stock list
#-----

# remove stocks with short time series
sts <- subset(isa, Year %in% dy & !is.na(FishingPressure))$FishStock
# remove short time series (less than 5 years)
sts <- table(sts)
sts <- names(sts)[sts<5] # No time series are shorter than 5 years
#"nep.fu.2324"
# remove also nep.fu.3-4, assessment area is not stable so doesn't have 5 years of
comparable data
#also removing nep.fu.13 as 2020 assessment is not finalized yet, information are
available only for the firth of Clyde, but a single estimate for Firth of Clyde and Sound of
Jura was estimated in the SAG so waiting for corrections from ICES: today 11/03/2021 we
remove the stock until further notice
# sts <- c(sts, "nep.fu.3-4", "nep.fu.13")
sts <- c(sts)

# stocks to retain
stkToRetain <- unique(isa12sf$FishStock)[-1]
stkToRetain <- stkToRetain[!(stkToRetain %in% sts)]
stkToRetain <- c(stkToRetain, "por.27.nea", "rju.27.7de")
stkToRetain <- sort(stkToRetain)

```

```

#-----
# subset assessments
#-----
# filtering
saeu <- subset(isa, FishStock %in% stkToRetain)

# Exclude data prior to 2017 for nep.fu.3-4 below is a text from the advice sheet to justify
it)
# The area of the Norway lobster ground surveyed has changed over time, with spatial
changes between 2013 and 2014 and a 27% increase in the area between 2016 and 2017.
This implies that the
# harvest rate was overestimated and that abundance was underestimated before 2017)
saeu <- saeu[!(saeu$FishStock=="nep.fu.3-4" & saeu$Year<=2016),]

# reporting
stkToDrop <- unique(isa[!(isa$FishStock %in% stkToRetain), c("FishStock", "EcoRegion",
"DataCategory")])
if (savecsv) write.csv(stkToDrop, file="NEA/results/stkToDropBySampFrame-nea.csv")
stkToRetain <- unique(isa[isa$FishStock %in% stkToRetain, c("FishStock", "EcoRegion",
"DataCategory")])
if (savecsv) write.csv(stkToRetain, file="NEA/results/stkToRetainBySampFrame-nea.csv")

# check what's available
table(saeu[,c("FishingPressureDescription", "StockSizeDescription")])

#=====
# process data for indicators
#=====

#-----
# fixing BMSYescapment not reported by ICES
#-----
saeu$MSYBescapement <- NA

# NOP 34, MSYBescapement not available so Blim used as a reference
saeu[saeu$FishStock == "nop.27.3a4", c("StockSize", "MSYBescapement")] <-
saeu[saeu$FishStock == "nop.27.3a4", c("Low_StockSize", "Blim")]

# ANE BISC - need to add value from ss, using upper trigger from 2019 as proxy for
MSYBescapement
saeu[saeu$FishStock == "ane.27.8", "MSYBescapement"] <- 89000

# according to the sumsheets SAN and SPR-NSEA use Bpa for MSYBescapement
saeu[saeu$FishStock %in%
c("san.sa.1r", "san.sa.2r", "san.sa.3r", "san.sa.4", "spr.27.3a4"), "MSYBescapement"] <-
saeu[saeu$FishStock %in%
c("san.sa.1r", "san.sa.2r", "san.sa.3r", "san.sa.4", "spr.27.3a4"), "Bpa"]

#-----
# fixing Recruitments of 0
#-----
saeu[saeu$Recruitment==0 & !is.na(saeu$Recruitment), "Recruitment"] #<- NA

#-----
# Bref
#-----

```

```

# check MSYBtrigger approx. Bpa, need some boundaries for rounding
stksBpaMSYBtrigger <- unique(saeu[saeu$MSYBtrigger/saeu$Bpa < 1.05 &
saeu$MSYBtrigger/saeu$Bpa > 0.95, c("FishStock", "Bpa", "MSYBtrigger")])
stksBpaMSYBtrigger <- stksBpaMSYBtrigger[order(stksBpaMSYBtrigger$FishStock),]
if (savecsv) write.csv(stksBpaMSYBtrigger, file="NEA/results/stksBpaMSYBtrigger.csv")

# create field
saeu$Bref <- saeu$MSYBtrigger
# if MSYBtrigger is set at Bpa level set to NA, with the exception
# of a couple of stocks which were explicitly set that way by the AWG
saeu$Bref[saeu$MSYBtrigger==saeu$Bpa & !(saeu$FishStock %in% c("hom.27.9a",
"pra.27.3a4a", "sol.27.7e"))] <- NA

# B escapement as Bref for relevant stocks
saeu$Bref[!is.na(saeu$MSYBescapement)] <-
saeu$MSYBescapement[!is.na(saeu$MSYBescapement)]
saeu$Bref <- as.numeric(saeu$Bref)
# set 0 as NA
saeu$Bref[saeu$Bref==0] <- NA
# if relative Bref = 1
saeu[saeu$StockSizeDescription == "B/Bmsy", "Bref"] <- 1

# Bpa
saeu$Brefpa <- saeu$Bpa
# some stocks don't have Bpa (it was set at MSYBtrigger level)
saeu$Brefpa[saeu$FishStock %in% c("hom.27.9a")] <- NA
# set 0 as NA
saeu$Brefpa[saeu$Brefpa==0] <- NA
# if relative Brefpa = 0.5
saeu[saeu$StockSizeDescription == "B/Bmsy", "Brefpa"] <- 0.5

#-----
# Fref
#-----
saeu$Fref <- saeu$FMSY
# no Fref for B escapement
saeu$Fref[!is.na(saeu$MSYBescapement)] <- NA
saeu$Fref <- as.numeric(saeu$Fref)
# set 0 as NA
saeu$Fref[saeu$Fref==0] <- NA
# if relative Fmsy must be 1
saeu[saeu$FishingPressureDescription %in% c("F/Fmsy", "HR/HRmsy"), "Fref"] <- 1

saeu$Frefpa <- saeu$Fpa
# no Fref for B escapement
saeu$Frefpa[!is.na(saeu$MSYBescapement)] <- NA
saeu$Frefpa <- as.numeric(saeu$Frefpa)
# set 0 as NA
saeu$Frefpa[saeu$Frefpa==0] <- NA
# if relative Fparef must be NA
saeu[saeu$FishingPressureDescription %in% c("F/Fmsy", "HR/HRmsy"), "Frefpa"] <- NA

#-----
# COMPUTE F/Fref and B/Bref | year + stock
#-----
saeu <- transform(saeu,
  indF = FishingPressure/Fref,
  indB=StockSize/Bref,
  indBpa=StockSize/Brefpa,

```

```

indFpa = FishingPressure/Frefpa)

# for dgs.27.nea, the advice uses the total biomass and a reference point associated to
that total biomass
saeu[saeu$FishStock=="dgs.27.nea","indBpa"] <-
saeu[saeu$FishStock=="dgs.27.nea","TBiomass"] /
saeu[saeu$FishStock=="dgs.27.nea","Bpa"]

# in case of escapement strategy MSY evaluated by SSB ~ Bref
saeu$indF[!is.na(saeu$MSYBescapement)] <-
saeu$Bref[!is.na(saeu$MSYBescapement)]/saeu$StockSize[!is.na(saeu$MSYBescapemen
t)]

saeu <- transform(saeu, sfFind=!is.na(indF))

#-----
# COMPUTE SBL | year + FishStock
#-----
saeu$SBL <- !(saeu$indFpa > 1 | saeu$indBpa < 1)
# if one is NA SBL can't be inferred
saeu$SBL[is.na(saeu$indFpa) | is.na(saeu$indBpa)] <- NA
# no SBL for B escapement
saeu$SBL[!is.na(saeu$MSYBescapement)] <- NA
saeu <- transform(saeu, sfSBL=!is.na(SBL))

#-----
# COMPUTE CFP objectives | year + FishStock
#-----
saeu$CFP <- !(saeu$indF > 1 | saeu$indB < 1)
# if one is NA CFP can't be inferred
saeu$CFP[is.na(saeu$indF) | is.na(saeu$indB)] <- NA
# no CFP for B escapement
saeu$CFP[!is.na(saeu$MSYBescapement)] <- NA
saeu <- transform(saeu, sfCFP=!is.na(CFP))

#-----
# final dataset
#-----
# remove WG projections
saeu <- saeu0 <- subset(saeu, Year <= fnlYear)
saeu <- subset(saeu, Year>=iniYear & assessmentYear %in% vay & sfFind)

#-----
# project stock status up to last year in cases missing
#-----

saeu <- projectStkStatus(saeu, vpy)
if (savecsv) write.csv(saeu, "NEA/data/saeu.csv", row.names=F)
if (savecsv) write.csv(saeu0, "NEA/data/saeu0.csv", row.names=F)

#=====
# Indicators (design based)
#=====

#-----
# Number of stocks (remove projected years)

```

```

#-----
df0 <- saeu[!saeu$projected,]
inStks <- getNoStks(df0, "FishStock", length)

# check for potential duplicates
mo1 <- df0[df0$EcoRegion == "Greater North Sea", c("EcoRegion", "FishStock", "Year")]
table(mo1[,c("FishStock", "Year")])

if (savegraph) png("NEA/results/figNEAI0a.png", 1800, 1200, res=300)
ggplot(subset(inStks, EcoRegion=="ALL"), aes(x=Year, y=N)) +
  geom_line() +
  ylab("No. of stocks") +
  xlab("") +
  ylim(c(0,85)) +
  sc +
  th
if (savegraph) dev.off()

# time series
# check stocks with non continuous time series
# plot needs to be fixed manually but should be possible to auto
stks_ncts <- tapply(df0$Year, df0$FishStock, function(x){
  !(max(x) - min(x) + 1 == length(x))
})
stks_ncts <- names(stks_ncts)[stks_ncts]

if (savegraph) png("NEA/results/figNEAI0b.png", 3000, 4500, res=300, bg =
"transparent")
ggplot(df0, aes(Year, reorder(FishStock, desc(FishStock)))) +
  geom_line() +
  geom_point(data=aggregate(list(Year=df0$Year, EcoRegion=df0$EcoRegion),
    by=list(FishStock=df0$FishStock), max)) +
  # NEP missing years
  geom_line(data=data.frame(Year=2009:2013, FishStock="nep.fu.14",
    EcoRegion="Celtic Seas"), color="white") +
  geom_line(data=data.frame(Year=2007:2009, FishStock="nep.fu.13",
    EcoRegion="Celtic Seas"), color="white") +
  geom_line(data=data.frame(Year=2003:2005, FishStock="nep.fu.13",
    EcoRegion="Celtic Seas"), color="white") +
  geom_point(data=data.frame(Year=2003, FishStock="nep.fu.13",
    EcoRegion="Celtic Seas"), size=0.3) +
  ylab("") +
  xlab("Year") +
  sc +
  th +
  facet_grid(EcoRegion~., switch="y", space="free_y", scales="free_y") +
  theme(strip.placement="outside", strip.background.y=element_blank(),
    panel.spacing.y=unit(0.05, "lines"))
if (savegraph) dev.off()

if (savecsv) write.csv(reshape2::dcast(inStks, EcoRegion~Year, value.var='N'),
file="NEA/results/tabNEAI0.csv", row.names=FALSE)

#-----
# (I1) Stocks F > Fmsy and (I2) Stocks F <= Fmsy
#-----
fInda <- cbind(getNoStks(saeu, "indF", function(x) sum(x>1)), indicator="F>Fmsy")
fIndb <- cbind(getNoStks(saeu, "indF", function(x) sum(x<=1)), indicator="F≤FMSY")

```

```

fIndab <- rbind(fInda, fIndb)

# plot
if (savegraph) png("NEA/results/figNEAI1-2.png", 1800, 1200, res=300)
ggplot(subset(fIndab, EcoRegion=='ALL'), aes(x=Year, y=N, fill=indicator)) +
  geom_area() +
  expand_limits(y=0) +
  #geom_point(aes(x=iniYear:fnlYear, y=N[1:18])) +
  #geom_point(aes(x=fnlYear, y=N[length(N)]), size=2) +
  ggtitle(expression(paste("N stocks > ", F[MSY], " and N stocks ≤ ", F[MSY]))) +
  ylab("No. of stocks") +
  xlab("") +
  ylim(c(0,85)) +
  sc +
  th +
  scale_fill_grey(start=0.3, end=0.7)
if (savegraph) dev.off()

# plot
if (savegraph) png("NEA/results/figNEAI1-2b.png", 2400, 1200, res=300)
ggplot(subset(fIndab, EcoRegion != 'ALL'), aes(x=Year, y=N, fill=indicator)) +
  geom_area() +
  facet_grid(.~EcoRegion) +
  ggtitle(expression(paste("N stocks > ", F[MSY], " and N stocks ≤ ", F[MSY]))) +
  ylab("No. of stocks") +
  xlab("") +
  sc +
  ylim(0, 30) +
  th +
  scale_fill_grey(start=0.3, end=0.7)
if (savegraph) dev.off()

# table
if (savecsv) write.csv(reshape2::dcast(fInda, EcoRegion~Year, value.var='N'),
file="NEA/results/tabNEAI1.csv", row.names=FALSE)
if (savecsv) write.csv(reshape2::dcast(fIndb, EcoRegion~Year, value.var='N'),
file="NEA/results/tabNEAI2.csv", row.names=FALSE)

#-----
# (I3) Stocks outside SBL and (I4) Stocks inside SBL
#-----
fIndc <- cbind(getNoStks(saeu, "SBL", function(x) sum(!x, na.rm=TRUE)),
indicator="F>FPA | B<BPA")
fIndd <- cbind(getNoStks(saeu, "SBL", function(x) sum(x, na.rm=TRUE)),
indicator="F≤FPA & B≥BPA")
fIndcd <- rbind(fIndc, fIndd)

# plot
if (savegraph) png("NEA/results/figNEAI3-4.png", 1800, 1200, res=300)
ggplot(subset(fIndcd, EcoRegion=='ALL'), aes(x=Year, y=N, fill=indicator)) +
  geom_area() +
  expand_limits(y=0) +
  #geom_point(aes(x=iniYear:fnlYear, y=N[1:18])) +
  #geom_point(aes(x=fnlYear, y=N[length(N)]), size=2) +
  ggtitle(expression("N of stocks complying or not with PA")) +
  ylab("No. of stocks") +
  xlab("") +
  ylim(c(0,85)) +

```



```

    sc +
    th +
    scale_fill_grey(start=0.3, end=0.7)
if (savegraph) dev.off()

# plot
if (savegraph) png("NEA/results/figNEAI3-4b.png", 2400, 1200, res=300)
ggplot(subset(fIndcd, EcoRegion != 'ALL'), aes(x=Year, y=N, fill=indicator)) +
  geom_area() +
  facet_grid(.~EcoRegion) +
  ggtitle(expression("N of stocks complying or not with PA")) +
  ylab("No. of stocks") +
  xlab("") +
  sc +
  ylim(0, 30) +
  th +
  scale_fill_grey(start=0.3, end=0.7)
if (savegraph) dev.off()

# table
if (savecsv) write.csv(reshape2::dcast(fIndc, EcoRegion~Year, value.var='N'),
file="NEA/results/tabNEAI3.csv", row.names=FALSE)
if (savecsv) write.csv(reshape2::dcast(fIndd, EcoRegion~Year, value.var='N'),
file="NEA/results/tabNEAI4.csv", row.names=FALSE)

#-----
# (I5) Stocks outside CFP objectives
#-----
fInde <- cbind(getNoStks(saeu, "CFP", function(x) sum(!x, na.rm=TRUE)), indicator =
"F>FMSY | B<BMSY")
fIndf <- cbind(getNoStks(saeu, "CFP", function(x) sum(x, na.rm=TRUE)), indicator =
"F≤FMSY & B≥BMSY")

fIndef <- rbind(fInde, fIndf)
## plot
if (savegraph) png("NEA/results/figNEAI5-6.png", 1800, 1200, res=300)
ggplot(subset(fIndef, EcoRegion=='ALL'), aes(x=Year, y=N, fill=indicator)) +
  geom_area() +
  expand_limits(y=0) +
  #geom_point(aes(x=iniYear:fniYear, y=N[1:18])) +
  #geom_point(aes(x=fniYear, y=N[length(N)]), size=2) +
  ggtitle(expression("N of stocks complying or not with CFP")) +
  ylab("No. of stocks") +
  xlab("") +
  ylim(c(0,85)) +
  sc +
  th +
  scale_fill_grey(start=0.3, end=0.7)
if (savegraph) dev.off()

# plot
if (savegraph) png("NEA/results/figNEAI5-6b.png", 2400, 1200, res=300)
ggplot(subset(fIndef, EcoRegion != 'ALL'), aes(x=Year, y=N, fill=indicator)) +
  geom_area() +
  facet_grid(.~EcoRegion) +
  ggtitle(expression("N of stocks complying or not with CFP")) +
  ylab("No. of stocks") +
  xlab("") +
  sc +

```

```

      ylim(0, 30) +
      th +
      scale_fill_grey(start=0.3, end=0.7)
if (savegraph) dev.off()

# table
if (savecsv) write.csv(reshape2::dcast(fInde, EcoRegion~Year, value.var='N'),
file="NEA/results/tabNEAI5.csv", row.names=FALSE)
if (savecsv) write.csv(reshape2::dcast(fIndf, EcoRegion~Year, value.var='N'),
file="NEA/results/tabNEAI6.csv", row.names=FALSE)

if (savedata) save.image("NEA/results/saeu.RData")

# =====
# Indicators (model based)
# =====

#-----
# (I7) F/Fmsy model
#-----
idx <- saeu$FishingPressureDescription %in% c("F", "F/Fmsy")
saeu$sfI7 <- idx & is.na(saeu$MSYBescapement)
df0 <- saeu[saeu$sfI7,]

# png("./FFmsyNEA_stock.png", 600, 600)
# xyplot(df0$indF~df0$Year|df0$FishStock, xlab = "Years", ylab = "F/Fmsy", lwd=2,
type=c("l"), scales=list(y=list(relation="free")))
# dev.off()

if (savegraph) png("NEA/results/FFmsyNEA_stock_single.png", 1000, 600)
#xyplot(df0$indF~df0$Year, group=df0$FishStock, xlab = "Years", ylab = "F/Fmsy",
lwd=2, type=c("l"), auto.key=list(space = "right", points = FALSE, lines = TRUE))
#columns=2,
ggplot(data=df0,
      aes(x=Year,
          y=indF)
) +
  geom_line(aes(color=FishStock)) +
  xlab("Years")+
  ylab("F/Fmsy")+
  theme(legend.position = "right") +
  labs(color = "Stock Code")+
  ggtitle("F/Fmsy")

if (savegraph) dev.off()

df0$Year <- factor(df0$Year)
yrs <- levels(df0$Year)
nd <- data.frame(Year=factor(yrs))

# fit
ifit <- glmer(indF ~ Year + (1|FishStock), data = df0, family = Gamma("log"),
control=glmerControl(optimizer="nllminbwrap"))
if (rundiags) runDiagsME(ifit, "FishStock", df0, "NEA/results/diagNEAI7.pdf", nc, nd)

```

```

# bootstrap
stk <- unique(df0$FishStock)
ifit.bs <- split(1:it, 1:it)

if (bootstrap) {
  ifit.bs <- mclapply(ifit.bs, function(x){
    stk <- sample(stk, replace=TRUE)
    df1 <- df0[0,]
    for(i in stk) df1 <- rbind(df1, subset(df0, FishStock==i))
    fit <- glmer(indF ~ Year + (1|FishStock), data = df1, family = Gamma("log"),
control=glmerControl(optimizer="nlminbwrap"))
    v0 <- predict(fit, re.form=~0, type="response", newdata=nd)
    if(length(fit@optinfo$conv$lme4)>0) v0[] <- NA
    v0
  }, mc.cores=nc)
}

ifitm <- do.call("rbind", ifit.bs)
ifitq <- apply(ifitm, 2, quantile, qtl, na.rm=TRUE)
ifitq <- cbind(Year=as.numeric(ysr), as.data.frame(t(ifitq)))

# plot
if (savegraph) png("NEA/results/figNEAI7.png", 1800, 1200, res=300)
ggplot(ifitq, aes(x=Year)) +
  geom_ribbon(aes(ymin = `2.5%`, ymax = `97.5%`), fill="gray", alpha=0.60) +
  geom_ribbon(aes(ymin = `25%`, ymax = `75%`), fill="gray", alpha=0.95) +
  geom_line(aes(y=`50%`)) + expand_limits(y=0) +
  geom_point(aes(x=Year[1], y=`50%`[1])) +
  geom_point(aes(x=Year[length(Year)], y=`50%`[length(`50%`)]), size=2) +
  geom_hline(yintercept = 1, linetype=2) +
  ylab(expression(F/F[MSY])) +
  ylim(0, 3) +
  xlab("") +
  theme(legend.position = "none") +
  sc +
  th
if (savegraph) dev.off()

# table
tb0 <- t(ifitq)[-1,]
colnames(tb0) <- ifitq[,1]
if (savecsv) write.csv(tb0, file="NEA/results/tabNEAI7.csv")

# leave one out
loo_ffmsy_eu <- data.frame(
Year=2003:2021,
"ank.27.78abd" =NA,
"ank.27.8c9a" =NA,
"bli.27.5b67" =NA,
"cod.27.22-24" =NA,
"cod.27.47d20" =NA,
"cod.27.6a" =NA,
"cod.27.7a" =NA,
"cod.27.7e-k" =NA,
"had.27.46a20" =NA,
"had.27.7a" =NA,
"had.27.7b-k" =NA,
"her.27.20-24" =NA,

```

```

"her.27.25-2932"      =NA,
"her.27.28"           =NA,
"her.27.3031"         =NA,
"her.27.3a47d"        =NA,
"her.27.irls"         =NA,
"her.27.nirs"         =NA,
"hke.27.3a46-8abd"    =NA,
"hke.27.8c9a"         =NA,
"hom.27.2a4a5b6a7a-ce-k8" =NA,
"hom.27.9a"           =NA,
"ldb.27.8c9a"         =NA,
"lez.27.4a6a"         =NA,
"lez.27.6b"          =NA,
"mac.27.nea"          =NA,
"meg.27.7b-k8abd"     =NA,
"meg.27.8c9a"         =NA,
"mon.27.78abd"        =NA,
"mon.27.8c9a"         =NA,
"nep.fu.25"           =NA,
"nep.fu.2627"         =NA,
"nep.fu.31"           =NA,
"ple.27.21-23"        =NA,
"ple.27.24-32"        =NA,
"ple.27.420"          =NA,
"ple.27.7a"           =NA,
"ple.27.7d"           =NA,
"pok.27.3a46"         =NA,
"por.27.nea"          =NA,
"pra.27.3a4a"         =NA,
"rju.27.7de"          =NA,
"sol.27.20-24"        =NA,
"sol.27.4"            =NA,
"sol.27.7a"           =NA,
"sol.27.7d"           =NA,
"sol.27.7e"           =NA,
"sol.27.7fg"          =NA,
"sol.27.8ab"          =NA,
"spr.27.22-32"        =NA,
"tur.27.4"            =NA,
"whb.27.1-91214"      =NA,
"whg.27.47d"          =NA,
"whg.27.6a"           =NA,
"whg.27.7a"           =NA,
"whg.27.7b-ce-k"     =NA,
"wit.27.3a47d"        =NA)

```

```

for (i in 1:57)
{
  stk.rm <- stk[i]
  fit <- glmer(indF ~ Year + (1|FishStock), data = df0[df0$FishStock!=stk.rm,], family =
  Gamma("log"), control=glmerControl(optimizer="nlminbwrap"))
  loo_ffmsy_eu[, (i+1)] <- predict(fit, re.form=~0, type="response", newdata=nd)
  print(stk.rm)
}

```

```

plot(x=loo_ffmsy_eu[,1], y=loo_ffmsy_eu[,2], type="l", ylim=c(0,2), main="F/FMSY
leave one out", xlab="Years", ylab="F/FMSY")
for (i in 3:58)
{

```

```

      lines(x=loo_ffmsy_eu[,1], y=loo_ffmsy_eu[,i])
    }
  abline(h=1, col="black", lty=2)

  savePlot("NEA/results/FFMSY_eu/loo_FFMSY.png", type="png")

  # Remove the biomass dynamics from the dataset
  df_noBDM <- df0[!(df0$FishStock %in% c("lez.27.4a6a", "lez.27.6b", "nep.fu.25",
    "nep.fu.2627", "nep.fu.31", "ple.27.24-32", "por.27.nea", "rju.27.7de")),]
  ifit <- glmer(indF ~ Year + (1|FishStock), data = df_noBDM, family = Gamma("log"),
    control=glmerControl(optimizer="nlminbwrap"))
  if (rundiags) runDiagsME(ifit, "FishStock", df_noBDM,
    "NEA/results/no_BDM/diagNEAI7.pdf", nc, nd)

  # bootstrap
  stk <- unique(df_noBDM$FishStock)
  ifit.bs <- split(1:it, 1:it)

  if (bootstrap) {
    ifit.bs <- mclapply(ifit.bs, function(x){
      stk <- sample(stk, replace=TRUE)
      df1 <- df_noBDM[0,]
      for(i in stk) df1 <- rbind(df1, subset(df_noBDM, FishStock==i))
      fit <- glmer(indF ~ Year + (1|FishStock), data = df1, family = Gamma("log"),
        control=glmerControl(optimizer="nlminbwrap"))
      v0 <- predict(fit, re.form=~0, type="response", newdata=nd)
      if(length(fit@optinfo$conv$lme4)>0) v0[] <- NA
      v0
    }, mc.cores=nc)
  }

  ifitm <- do.call("rbind", ifit.bs)
  ifitq <- apply(ifitm, 2, quantile, qtl, na.rm=TRUE)
  ifitq <- cbind(Year=as.numeric( yrs), as.data.frame(t(ifitq)))

  # plot
  if (savegraph) png("NEA/results/no_BDM/figNEAI7.png", 1800, 1200, res=300)
  ggplot(ifitq, aes(x=Year)) +
    geom_ribbon(aes(ymin = `2.5%`, ymax = `97.5%`), fill="gray", alpha=0.60) +
    geom_ribbon(aes(ymin = `25%`, ymax = `75%`), fill="gray", alpha=0.95) +
    geom_line(aes(y=`50%`)) + expand_limits(y=0) +
    geom_point(aes(x=Year[1], y=`50%`[1])) +
    geom_point(aes(x=Year[length(Year)], y=`50%`[length(`50%`)]), size=2) +
    geom_hline(yintercept = 1, linetype=2) +
    ylab(expression(F/F[MSY])) +
    ylim(0, 3) +
    xlab("") +
    theme(legend.position = "none") +
    sc +
    th
  if (savegraph) dev.off()

  # Remove the 3 stocks that
  df_no3BDM <- df0[!(df0$FishStock %in% c("ple.27.24-32", "por.27.nea", "rju.27.7de")),]
  ifit <- glmer(indF ~ Year + (1|FishStock), data = df_no3BDM, family = Gamma("log"),
    control=glmerControl(optimizer="nlminbwrap"))
  if (rundiags) runDiagsME(ifit, "FishStock", df_no3BDM,
    "NEA/results/FFMSY_eu/diagNEAI7_nople_nopor_norju.pdf", nc, nd)

```

```

# bootstrap
stk <- unique(df_no3BDM$FishStock)
ifit.bs <- split(1:it, 1:it)

if (bootstrap) {
  ifit.bs <- mclapply(ifit.bs, function(x){
    stk <- sample(stk, replace=TRUE)
    df1 <- df_no3BDM[0,]
    for(i in stk) df1 <- rbind(df1, subset(df_no3BDM, FishStock==i))
    fit <- glmer(indF ~ Year + (1|FishStock), data = df1, family = Gamma("log"),
control=glmerControl(optimizer="nlminbwrap"))
    v0 <- predict(fit, re.form=~0, type="response", newdata=nd)
    if(length(fit@optinfo$conv$lme4)>0) v0[] <- NA
    v0
  }, mc.cores=nc)
}

ifitm <- do.call("rbind", ifit.bs)
ifitq <- apply(ifitm, 2, quantile, qtl, na.rm=TRUE)
ifitq <- cbind(Year=as.numeric(ysr), as.data.frame(t(ifitq)))

# plot
if (savegraph) png("NEA/results/FFMSY_eu/figNEAI7_nople_nopor_norju.png", 1800,
1200, res=300)
ggplot(ifitq, aes(x=Year)) +
  geom_ribbon(aes(ymin = `2.5%`, ymax = `97.5%`), fill="gray", alpha=0.60) +
  geom_ribbon(aes(ymin = `25%`, ymax = `75%`), fill="gray", alpha=0.95) +
  geom_line(aes(y=`50%`)) + expand_limits(y=0) +
  geom_point(aes(x=Year[1], y=`50%`[1])) +
  geom_point(aes(x=Year[length(Year)], y=`50%`[length(`50%`)]), size=2) +
  geom_hline(yintercept = 1, linetype=2) +
  ylab(expression(F/F[MSY])) +
  ylim(0, 3) +
  xlab("") +
  theme(legend.position = "none") +
  sc +
  th
if (savegraph) dev.off()

# cat 1-2 stocks having SPiCT assessments
spict.ls <- unique(saeu[saeu$FMSY==1,c("FishStock","DataCategory","Report")])
spict.ls$model <- NA
spict.ls <- spict.ls[!is.na(spict.ls$FishStock),]
spict.ls[spict.ls$FishStock=="lez.27.4a6a","model"] <- "Bayesian state-space biomass
dynamic model"
spict.ls[spict.ls$FishStock=="lez.27.6b","model"] <- "SPiCT"
spict.ls[spict.ls$FishStock=="nep.fu.25","model"] <- "SPiCT"
spict.ls[spict.ls$FishStock=="nep.fu.2627","model"] <- "SPiCT"
spict.ls[spict.ls$FishStock=="nep.fu.31","model"] <- "SPiCT"
spict.ls[spict.ls$FishStock=="ple.27.24-32","model"] <- "SPiCT"
spict.ls[spict.ls$FishStock=="por.27.nea","model"] <- "SPiCT"
spict.ls[spict.ls$FishStock=="pra.27.3a4a","model"] <- "Quarterly, two-area length-based
analytical assessment (Stock Synthesis 3) "
spict.ls[spict.ls$FishStock=="rju.27.7de","model"] <- "SPiCT"
spict.ls[spict.ls$FishStock=="ank.27.8c9a","model"] <- "SPiCT"

unique(saeu[saeu$FishingPressureDescription=="F/Fmsy",c("FishStock")])

```

```

unique(isa[isa$DataCategory>=3 & isa$DataCategory<4,"FishStock"])

#-----
# (I7b) F/Fmsy model regional
#-----
df0 <- saeu[saeu$sfI7,]
df0$Year <- factor(df0$Year)
yrs <- levels(df0$Year)
nd <- data.frame(Year=factor(yrs))

ifitRegional <- lapply(split(df0, df0$EcoRegion), function(x){
  # fit model
  ifit <- glmer(indF ~ Year + (1|FishStock), data = x, family = Gamma("log"),
control=glmerControl(optimizer="nlminbwrap"))
  # no variance with bootstrap due to small number of stocks
  ifit.pred <- predict(ifit, re.form=~0, type="response", newdata=nd)
  # output
  list(ifit=ifit, ifit.pred=ifit.pred)
})

# naming including No of stocks
No <- lapply(split(df0, df0$EcoRegion), function(x) length(unique(x$FishStock)))
names(ifitRegional) <- paste(names(No), " (", No, ")", sep="")

lst0 <- lapply(ifitRegional, "[", "ifit.pred")
fIndfr <- data.frame(EcoRegion=rep(names(lst0), lapply(lst0, length)), N=unlist(lst0),
Year=as.numeric(as.character(nd[,1])))

# plot
if (savegraph) png("NEA/results/figNEAI7b.png", 2400, 1200, res=300)
ggplot(fIndfr, aes(x=Year, y=N)) +
  geom_line() +
  facet_grid(.~EcoRegion) +
  ylab(expression(F/F[MSY])) +
  xlab("") +
  sc +
  ylim(0, 2.5) +
  th
if (savegraph) dev.off()

# table
if (savecsv) write.csv(reshape2::dcast(fIndfr, EcoRegion~Year, value.var='N'),
file="NEA/results/tabNEAI7b.csv", row.names=FALSE)

#-----
# (I7out) F/Fmsy stocks outside EU
#-----
#df0 <- subset(isa, (EcoRegion %in% c("Arctic Ocean", "Iceland, Greenland and Faroes")
| FishStock=="her.27.1-24a514a") & Year>=iniYear & Year<=fmlYear & AssessmentYear
%in% vay)
df0 <- subset(isa, (EcoRegion %in% c("Arctic Ocean", "Iceland, Greenland and Faroes") |
FishStock=="her.27.1-24a514a") & FishStock!="pra.27.1-2" & Year>=iniYear &
Year<=fmlYear & AssessmentYear %in% vay)

df0$Fref <- as.numeric(df0$FMSY)
df0 <- transform(df0, indF = FishingPressure/Fref, sfFind=!is.na(FishingPressure/Fref))
idx <- df0$FishingPressureDescription %in% c("F", "F/Fmsy") & df0$sfFind
df0 <- df0[idx,]
"Iceland, Greenland and Faroes"

```

```

"Iceland, Greenland and Faroes"
# check data series is complete
df0 <- projectStkStatus(df0, vpy)
table(df0[,c("FishStock", "Year")])

if (savegraph) png("NEA/results/FFmsyOut.png", 600, 600)
xyplot(df0$indF~df0$Year|df0$FishStock, xlab = "Years", ylab = "F/Fmsy", lwd=2,
type=c("l")) + latticeExtra::layer(panel.abline(h=1, lty = 2))#,
scales=list(y=list(relation="free"))
if (savegraph) dev.off()

# pdf("./FFmsyOut_stock_single.pdf", 12, 12)
# xyplot(df0$indF~df0$Year, group=df0$FishStock, xlab = "Years", ylab = "F/Fmsy",
lwd=2, type=c("l"), auto.key=list(space = "right", points = FALSE, lines = TRUE))
# dev.off()

# create year variable for prediction
df0$Year <- factor(df0$Year)
yrs <- levels(df0$Year)
nd <- data.frame(Year=factor(yrs))

# fit
ifitout <- glmer(indF ~ Year + (1|FishStock), data = df0, family = Gamma("log"),
control=glmerControl(optimizer="nlminbwrap"))
if (rundiags) runDiagsME(ifitout, "FishStock", df0, "NEA/results/diagNEAI7out.pdf", nc, nd)

# bootstrap
stk <- unique(df0$FishStock)
ifitout.bs <- split(1:it, 1:it)
if (bootstrap) {
  ifitout.bs <- mclapply(ifitout.bs, function(x){
    stk <- sample(stk, replace=TRUE)
    df1 <- df0[0,]
    for(i in stk) df1 <- rbind(df1, subset(df0, FishStock==i))
    fit <- glmer(indF ~ Year + (1|FishStock), data = df1, family = Gamma("log"),
control=glmerControl(optimizer="nlminbwrap"))
    v0 <- predict(fit, re.form=~0, type="response", newdata=nd)
    if(length(fit@optinfo$conv$lme4)>0) v0[] <- NA
    v0
  }, mc.cores=nc)
}

ifitm <- do.call("rbind", ifitout.bs)
ifitq <- apply(ifitm, 2, quantile, qtl, na.rm=TRUE)
ifitq <- cbind(Year=as.numeric(yrs), as.data.frame(t(ifitq)))

# plot
if (savegraph) png("NEA/results/figNEAI7out.pdf.png", 1800, 1200, res=300)
ggplot(ifitq, aes(x=Year)) +
  geom_ribbon(aes(ymin = `2.5%`, ymax = `97.5%`), fill="gray", alpha=0.60) +
  geom_ribbon(aes(ymin = `25%`, ymax = `75%`), fill="gray", alpha=0.95) +
  geom_line(aes(y=`50%`)) + expand_limits(y=0) +
  geom_point(aes(x=Year[1], y=`50%`[1])) +
  geom_point(aes(x=Year[length(Year)], y=`50%`[length(`50%`)]), size=2) +
  ylab(expression(F/F[MSY])) +
  geom_hline(yintercept = 1, linetype=2) +
  ylim(0, 3) +
  xlab("") +
  theme(legend.position = "none") +

```



```

sc +
th
if (savegraph) dev.off()

# table
tb0 <- t(iffitq)[-1,]
colnames(tb0) <- ifitq[,1]
if (savecsv) write.csv(tb0, file="NEA/results/tabNEAI7out.csv")

#leave one out
stk <- sort(unique(df0$FishStock))

loo_ffmsyout <- data.frame(
Year=2003:2021,
"aru.27.5a14" =NA,
"aru.27.5b6a" =NA,
"cod.21.1" =NA,
"cod.2127.1f14" =NA,
"cod.27.1-2" =NA,
"cod.27.5b1" =NA,
"ghl.27.561214" =NA,
"had.27.1-2" =NA,
"had.27.5b" =NA,
"her.27.1-24a514a" =NA,
"her.27.5a" =NA,
"lin.27.5a" =NA,
"lin.27.5b" =NA,
"pok.27.5b" =NA,
"pra.27.1-2" =NA,
"reg.27.561214" =NA,
"usk.27.5a14" =NA)

for (i in 1:17)
{
stk.rm <- stk[i]
fit <- glmer(indF ~ Year + (1|FishStock), data = df0[df0$FishStock!=stk.rm,], family =
Gamma("log"), control=glmerControl(optimizer="nlminbwrap"))
loo_ffmsyout[(i+1)] <- predict(fit, re.form=~0, type="response", newdata=nd)
print(stk.rm)
}

fit <- glmer(indF ~ Year + (1|FishStock), data = df0, family = Gamma("log"),
control=glmerControl(optimizer="nlminbwrap"))
loo_ffmsyout$all <- predict(fit, re.form=~0, type="response", newdata=nd)

plot(x=loo_ffmsyout[,1], y=loo_ffmsyout[,2], type="l", ylim=c(0,2), main="F/FMSY leave
one out outside EU waters\n red=without pra.27.1-2 \n blue=with all stocks",
xlab="Years", ylab="F/FMSY")
for (i in 3:dim(loo_ffmsyout)[2])
{
lines(x=loo_ffmsyout[,1], y=loo_ffmsyout[,i])
}
abline(h=1, col="black", lty=2)

lines(x=loo_ffmsyout[,1], y=loo_ffmsyout$pra.27.1.2, col="red", lwd=2)
lines(x=loo_ffmsyout[,1], y=loo_ffmsyout$all, col="blue", lwd=2)

```

```

savePlot("NEA/results/FFMSYout/loo_FFMSY_out.png", type="png")

#-----
# (I8) SSB model
#-----
saeu$sfI8 <- saeu$StockSizeDescription %in% c("SSB", "TSB")
df0 <- saeu[saeu$sfI8,]
df0$Year <- factor(df0$Year)
yrs <- levels(df0$Year)
nd <- data.frame(Year=factor(yrs))

# fit
ifitb <- glmer(StockSize ~ Year + (1|FishStock), data = df0, family = Gamma("log"),
control=glmerControl(optimizer="bobyqa")) #"nlminbwrap" had to change optimizer to
allow convergence
if (rundiags) runDiagsME(ifitb, "FishStock", df0, "NEA/results/diagNEAI8.pdf", nc, nd)

# bootstrap
stk <- unique(df0$FishStock)
ifitb.bs <- split(1:it, 1:it)
if (bootstrap) {ifitb.bs <- mclapply(ifitb.bs, function(x){
  stk <- sample(stk, replace=TRUE)
  df1 <- df0[0,]
  for(i in stk) df1 <- rbind(df1, subset(df0, FishStock==i))
  fit <- glmer(StockSize ~ Year + (1|FishStock), data = df1, family = Gamma("log"),
control=glmerControl(optimizer="bobyqa")) #"nlminbwrap" had to change optimizer to
allow convergence
  v0 <- predict(fit, re.form=~0, type="response", newdata=nd)
  if(length(fit@optinfo$conv$lme4)>0) v0[] <- NA
  v0
}, mc.cores=nc)}

ifitm <- do.call("rbind", ifitb.bs)
ifitm <- exp(log(ifitm)-median(log(ifitm[,1]), na.rm=TRUE))
ifitq <- apply(ifitm, 2, quantile, qtl, na.rm=TRUE)
ifitq <- cbind(Year=as.numeric(yrs), as.data.frame(t(ifitq)))

# plot
if (savegraph) png("NEA/results/figNEAI8.png", 1800, 1200, res=300)
ggplot(ifitq, aes(x=Year)) +
  geom_ribbon(aes(ymin = `2.5%`, ymax = `97.5%`), fill="gray", alpha=0.60) +
  geom_ribbon(aes(ymin = `25%`, ymax = `75%`), fill="gray", alpha=0.95) +
  geom_line(aes(y=`50%`)) +
  expand_limits(y=0) +
  geom_point(aes(x=Year[1], y=`50%`[1])) +
  geom_point(aes(x=Year[length(Year)], y=`50%`[length(`50%`)]), size=2) +
  geom_hline(yintercept = 1, linetype=2) +
  ylab(expression(B/B[2003])) +
  xlab("") +
  theme(legend.position = "none") +
  sc +
  th
if (savegraph) dev.off()

# table
tb0 <- t(ifitq)[-1,]
colnames(tb0) <- ifitq[,1]

```

```

if (savecsv) write.csv(tb0, file="NEA/results/tabNEAI8.csv")

#-----
# (I8b) SSB model regional
#-----
df0 <- saeu[saeu$sfI8,]
df0$Year <- factor(df0$Year)
yrs <- levels(df0$Year)
nd <- data.frame(Year=factor(yrs))

ifitbRegional <- lapply(split(df0, df0$EcoRegion), function(x){
  # fit model
  ifitb <- glmer(StockSize ~ Year + (1|FishStock), data = x, family = Gamma("log"),
    control=glmerControl(optimizer="bobyqa")) #nlminbwrap change optimizer for
    convergence (still one convergence issue due to gradient at 0.007 (tol=0.002))
  # no variance with bootstrap due to small number of stocks
  ifitb.pred <- predict(ifitb, re.form=~0, type="response", newdata=nd)
  # output
  list(ifitb=ifitb, ifitb.pred=ifitb.pred/ifitb.pred[nd==iniYear])
})

# naming including No of stocks
No <- lapply(split(df0, df0$EcoRegion), function(x) length(unique(x$FishStock)))
names(ifitbRegional) <- paste(names(No), " (", No, ")", sep="")

lst0 <- lapply(ifitbRegional, "[", "ifitb.pred")
fIndbr <- data.frame(EcoRegion=rep(names(lst0), lapply(lst0, length)), N=unlist(lst0),
  Year=as.numeric(as.character(nd[,1])))

# plot
if (savegraph) png("NEA/results/figNEAI8b.png", 2400, 1200, res=300)
ggplot(fIndbr, aes(x=Year, y=N)) +
  geom_line() +
  facet_grid(.~EcoRegion) +
  geom_hline(yintercept = 1, linetype=2) +
  ylab(expression(B/B[2003])) +
  xlab("") +
  theme(legend.position = "none") +
  sc +
  th
if (savegraph) dev.off()

# table
if (savecsv) write.csv(reshape2::dcast(fIndbr, EcoRegion~Year, value.var='N'),
  file="NEA/results/tabNEAI8b.csv", row.names=FALSE)

#-----
# (I10) Recruitment model
#-----
saeu0 <- saeu0[!saeu0$FishStock %in% "cod.27.24-32",] # excluded from the analysis
  due to the absence of F reference points
#saeu0$Recruitment <- as.numeric(saeu0$Recruitment)

saeu0$sfI10 <- !is.na(saeu0$Recruitment)
df0 <- saeu0[saeu0$sfI10,]
# data for table about stocks and indicators
sfI10 <- subset(df0, Year>=iniYear & Year<=fniYear)
sfI10 <- tapply(sfI10$Year, sfI10$FishStock, max)
sfI10 <- data.frame(FishStock=names(sfI10), Year=sfI10, variable="sfI10", value=TRUE)

```

```

# project and compute indicator
df0 <- projectStkStatus(df0, vpy)

for(i in (iniYear):fnyYear) df0 <- decadalR(df0, i)

df0 <- subset(df0, Year>=iniYear & Year<=fnyYear)
df0$Year <- factor(df0$Year)
yrs <- levels(df0$Year)
nd <- data.frame(Year=factor(yrs))

# fit
ifitr <- glmer(decadalR ~ Year + (1|FishStock), data = df0, family = Gamma("log"),
control=glmerControl(optimizer="nlminbwrap"))
if (rundiags) runDiagsME(ifitr, "FishStock", df0, "NEA/results/diagNEAI10.pdf", nc, nd)

# bootstrap
stk <- unique(df0$FishStock)
ifitr.bs <- split(1:it, 1:it)
if (bootstrap) {ifitr.bs <- mclapply(ifitr.bs, function(x){
  stk <- sample(stk, replace=TRUE)
  df1 <- df0[0,]
  for(i in stk) df1 <- rbind(df1, subset(df0, FishStock==i))
  fit <- glmer(decadalR ~ Year + (1|FishStock), data = df1, family = Gamma("log"),
control=glmerControl(optimizer="nlminbwrap"))
  v0 <- predict(fit, re.form=~0, type="response", newdata=nd)
  if(length(fit@optinfo$conv$lme4)>0) v0[] <- NA
  v0
}, mc.cores=nc)}

ifitm <- do.call("rbind", ifitr.bs)
ifitm <- exp(log(ifitm)-median(log(ifitm[,1]), na.rm=TRUE))
ifitq <- apply(ifitm, 2, quantile, qtl, na.rm=TRUE)
ifitq <- cbind(Year=as.numeric(yrs), as.data.frame(t(ifitq)))

#load("./RData_nea_newrec")
# plot
if (savegraph) png("NEA/results/figNEAI10.png", 1800, 1200, res=300)
ggplot(ifitq, aes(x=Year)) +
  geom_ribbon(aes(ymin = `2.5%`, ymax = `97.5%`), fill="gray", alpha=0.60) +
  geom_ribbon(aes(ymin = `25%`, ymax = `75%`), fill="gray", alpha=0.95) +
  geom_line(aes(y=`50%`)) +
  expand_limits(y=0) +
  geom_point(aes(x=Year[1], y=`50%`[1])) +
  geom_point(aes(x=Year[length(Year)], y=`50%`[length(`50%`)]), size=2) +
  geom_hline(yintercept = 1, linetype=2) +
  #ylab(expression(decadal_R/R[2003])) +
  ylab("Decadal recruitment (scaled to 2003)") +
  xlab("") +
  theme(legend.position = "none") +
  sc +
  th
if (savegraph) dev.off()

# table
tb0 <- t(ifitq)[-1,]
colnames(tb0) <- ifitq[,1]
if (savecsv) write.csv(tb0, file="NEA/results/tabNEAI10.csv")

#-----

```

```

# (I10b) R model regional
#-----

ifitrRegional <- lapply(split(df0, df0$EcoRegion), function(x){
  # fit model
  ifitr <- glmer(decadalR ~ Year + (1|FishStock), data = x, family = Gamma("log"),
control=glmerControl(optimizer="nlminbwrap"))
  # no variance with bootstrap due to small number of stocks
  ifitr.pred <- predict(ifitr, re.form=~0, type="response", newdata=nd)
  # output
  list(ifitr=ifitr, ifitr.pred=ifitr.pred/ifitr.pred[nd==iniYear])
})

# naming including No of stocks
No <- lapply(split(df0, df0$EcoRegion), function(x) length(unique(x$FishStock)))
names(ifitrRegional) <- paste(names(No), " (", No, ")", sep="")

lst0 <- lapply(ifitrRegional, "[[", "ifitr.pred")
fIndrr <- data.frame(EcoRegion=rep(names(lst0), lapply(lst0, length)), N=unlist(lst0),
Year=as.numeric(as.character(nd[,1])))

# plot
if (savegraph) png("NEA/results/figNEAI10b.png", 2400, 1200, res=300)
ggplot(fIndrr, aes(x=Year, y=N)) +
  geom_line() +
  facet_grid(.~EcoRegion) +
  geom_hline(yintercept = 1, linetype=2) +
  ylab("Decadal recruitment (scaled to 2003)") +
  xlab("") +
  theme(legend.position = "none") +
  sc +
  th
if (savegraph) dev.off()

# table
if (savecsv) write.csv(reshape2::dcast(fIndrr, EcoRegion~Year, value.var='N'),
file="NEA/results/tabNEAI10b.csv", row.names=FALSE)

#-----
# (I12) SSB model for cat 3
# >>> Check which are in sampling frame
# >>> Add to report Abundance indices also used
#-----

df0 <- subset(isa, !(EcoRegion %in% c("Arctic Ocean", "Iceland, Greenland and Faroes"))
& DataCategory>=3 & DataCategory<4 & StockSize>0 & Year>=iniYear & Year <= fnlYear
& AssessmentYear %in% vay & StockSizeDescription %in% c("Biomass index", "Biomass",
"Abundance index", "SSB", "TSB", "B/Bmsy", "Relative Biomass", "UWTV_index", "TSN"))
#"Relative BI (comb)", "Biomass Index (comb)", "LPUE", "standardized CPUE", "Relative
BI"

# remove stocks with short time series
sts <- table(df0$FishStock, df0$Year)
sts <- rownames(sts)[apply(sts, 1, sum)<5]
df0 <- subset(df0, !(FishStock %in% sts))

# id
sfI12 <- tapply(df0$Year, df0$FishStock, max)
sfI12 <- data.frame(FishStock=names(sfI12), Year=sfI12, variable="sfI12", value=TRUE)

```

```

# project for stocks without last two years estimates
# NEED CHECK
df0 <- projectStkStatus(df0, vpy)

# pre process for model
df0$Year <- factor(df0$Year)
yrs <- levels(df0$Year)
nd <- data.frame(Year=factor(yrs))

# fit
ifitb3 <- glmer(StockSize ~ Year + (1|FishStock), data = df0, family = Gamma("log"),
control=glmerControl(optimizer="nlminbwrap"))
if (rundiags) runDiagsME(ifitb3, "FishStock", df0, "NEA/results/diagNEAI12.pdf", nc, nd)

# bootstrap
stk <- unique(df0$FishStock)
ifitb3.bs <- split(1:it, 1:it)
if (bootstrap) {ifitb3.bs <- mclapply(ifitb3.bs, function(x){
  stk <- sample(stk, replace=TRUE)
  df1 <- df0[0,]
  for(i in stk) df1 <- rbind(df1, subset(df0, FishStock==i))
  fit <- glmer(StockSize ~ Year + (1|FishStock), data = df1, family = Gamma("log"),
control=glmerControl(optimizer="nlminbwrap"))
  v0 <- predict(fit, re.form=~0, type="response", newdata=nd)
  if(length(fit@optinfo$conv$lme4)>0) v0[] <- NA
  v0
}, mc.cores=nc)}

ifitm <- do.call("rbind", ifitb3.bs)
ifitm <- exp(log(ifitm)-median(log(ifitm[,1]), na.rm=TRUE))
ifitq <- apply(ifitm, 2, quantile, qtl, na.rm=TRUE)
ifitq <- cbind(Year=as.numeric(yrs), as.data.frame(t(ifitq)))

# plot
if (savegraph) png("NEA/results/figNEAI12.png", 1800, 1200, res=300)
ggplot(ifitq, aes(x=Year)) +
  geom_ribbon(aes(ymin = `2.5%`, ymax = `97.5%`), fill="gray", alpha=0.60) +
  geom_ribbon(aes(ymin = `25%`, ymax = `75%`), fill="gray", alpha=0.95) +
  geom_line(aes(y=`50%`)) +
  expand_limits(y=0) +
  geom_point(aes(x=Year[1], y=`50%`[1])) +
  geom_point(aes(x=Year[length(Year)], y=`50%`[length(`50%`)]), size=2) +
  geom_hline(yintercept = 1, linetype=2) +
  ylab(expression(B/B[2003])) +
  xlab("") +
  theme(legend.position = "none") +
  sc +
  th
if (savegraph) dev.off()

tb0 <- t(ifitq)[-1,]
colnames(tb0) <- ifitq[,1]
if (savecsv) write.csv(tb0, file="NEA/results/tabNEAI12.csv")

# leave one out
data.frame(sort(unique(df0$FishStock)))
cat3_loo <- data.frame(

```

Year=2003:2021,
 ane.27.9a = NA,
 anf.27.3a46=NA,
 aru.27.6b7_1012=NA,
 bll.27.22_32=NA,
 bll.27.3a47de=NA,
 boc.27.6_8=NA,
 bsf.27.nea=NA,
 bwp.27.2729_32=NA,
 bzq.27.2425=NA,
 bzq.27.2628=NA,
 cod.27.2.coasts=NA,
 cod.27.21=NA,
 dab.27.22_32=NA,
 dab.27.3a4=NA,
 fle.27.2223=NA,
 le.27.3a4=NA,
 gfb.27.nea=NA,
 gug.27.3a47d=NA,
 gur.27.3_8=NA,
 had.27.6b=NA,
 her.27.6an=NA,
 her.27.6as7bc=NA,
 hom.27.3a4bc7d=NA,
 lem.27.3a47d=NA,
 lin.27.346_91214=NA,
 nep.fu.2829=NA,
 nep.fu.30=NA,
 pil.27.7=NA,
 ple.27.7e=NA,
 ple.27.7fg=NA,
 ple.27.7h_k=NA,
 raj.27.1012=NA,
 rjc.27.3a47d=NA,
 rjc.27.6=NA,
 rjc.27.7afg=NA,
 rjc.27.8c=NA,
 rjc.27.9a=NA,
 rje.27.7fg=NA,
 rjh.27.4c7d=NA,
 rjh.27.9a=NA,
 rjm.27.3a47d=NA,
 rjm.27.67bj=NA,
 rjm.27.7ae_h=NA,
 rjm.27.8=NA,
 rjm.27.9a=NA,
 rjn.27.3a4=NA,
 rjn.27.8c=NA,
 rjn.27.9a=NA,
 rng.27.3a=NA,
 sbr.27.10=NA,
 sbr.27.9=NA,
 sdv.27.nea=NA,
 sho.27.67=NA,
 sho.27.89a=NA,
 sol.27.8c9a=NA,
 spr.27.7de=NA,
 syc.27.3a47d=NA,
 syc.27.67a_ce_j=NA,

```

syc.27.8abd=NA,
syc.27.8c9a=NA,
syt.27.67=NA,
tur.27.22_32=NA,
usk.27.3a45b6a7_912b=NA,
whg.27.3a=NA)

for (i in 2:dim(cat3_loo)[2])
{
  stkr <- colnames(cat3_loo)[i]
  fit <- glmer(StockSize ~ Year + (1|FishStock), data = df0[df0$FishStock!=stkr,], family
= Gamma("log"), control=glmerControl(optimizer="nlsminbwrap"))
  cat3_loo[,i] <- predict(fit, re.form=~0, type="response", newdata=nd)
  cat3_loo[,i] <- cat3_loo[,i]/cat3_loo[,1,i]
}

plot(x=cat3_loo$Year, y=cat3_loo[,2], type="l", ylim=c(0,2))
for (i in 3:65)
{
  lines(x=cat3_loo$Year, y=cat3_loo[,i])
}

savePlot("NEA/results/leave_one_out/category_3_BB2003.png", type="png")

#=====
# Bootstrap convergence problems
#=====

bootconv <- data.frame(
  indicator=c('F/Fmsy trends', 'F/Fmsy trends out', 'Biomass trends', 'Decadal
recruitment trends', "Biomass data category 3 trends"),
  convergence=c(sum(unlist(lapply(lapply(iffit.bs, is.na), sum))==0),
sum(unlist(lapply(lapply(iffitout.bs, is.na), sum))==0), sum(unlist(lapply(lapply(iffitb.bs,
is.na), sum))==0), sum(unlist(lapply(lapply(iffitb3.bs, is.na), sum))==0))/it
)

if (savecsv) write.csv(bootconv, file="NEA/results/bootconv.csv")

#=====
# Stocks used in each indicator
#=====
#sae1 <- as.data.table(saeu)
df0 <- reshape2::melt(saeu[!saeu$projected,], c('FishStock', 'Year'), c('sfFind', 'sfSBL',
'sfCFP', 'sfI7', 'sfI8'))
df0 <- do.call("rbind", lapply(split(df0, df0$FishStock), function(x) subset(x,
Year==max(x$Year))))
# fix year for I10 when assessment not from previous year
df1 <- sfI10
df1$Year <- subset(df0, FishStock %in% df1$FishStock & variable=="sfFind")$Year

# merge

```



```

df0 <- merge(df0, df1, all=TRUE)
df0 <- rbind(df0, sfI12)
levels(df0$variable) <- c('above/below Fmsy', 'in/out SBL', 'in/out CFP', 'F/Fmsy trends',
'Biomass trends', 'Decadal recruitment trends', "Biomass data category 3 trends")
stkPerIndicator <- reshape2::dcast(df0, FishStock+Year~variable, value.var='value')

# NOTE: this file must be fixed "by hand" to remove duplications
# created for the cat 1 stocks which were projected
# (no time to right code now ...)
if (savecsv) write.csv(stkPerIndicator, file="NEA/results/stkPerIndicator.csv")

# =====
# Coverage
# =====

# All stocks of relevance
stocks <- subset(saeu, Year==fnlYear)$FishStock
# All stocks with B indicator
bind_stocks <- subset(saeu, Year==fnlYear & !is.na(indB))$FishStock
# All stocks with F indicator - Same as stocks
find_stocks <- subset(saeu, Year==fnlYear & !is.na(indF))$FishStock
# All stocks with Bpa indicator
bpaind_stocks <- subset(saeu, Year==fnlYear & !is.na(indBpa))$FishStock
# All stocks with Fpa indicator - Same as stocks
fpaind_stocks <- subset(saeu, Year==fnlYear & !is.na(indFpa))$FishStock

# Current list
all_stocks <- unique(isa12sf$FishStock)
# ignore NA
all_stocks <- all_stocks[!is.na(all_stocks)]

# Which stocks to drop from all stocks
drop_stock <- all_stocks[!(all_stocks %in% stocks)]

# Which stocks to drop as no f indicator
drop_stock_f <- all_stocks[!(all_stocks %in% find_stocks)]

# Which stocks to drop as no b indicator
drop_stock_b <- all_stocks[!(all_stocks %in% bind_stocks)]

# Which stocks to drop as no fpa indicator
drop_stock_fpa <- all_stocks[!(all_stocks %in% fpaind_stocks)]

# Which stocks to drop as no bpa indicator
drop_stock_bpa <- all_stocks[!(all_stocks %in% bpaind_stocks)]

# Set dropped stocks to NA in FishStock column
isa12sf$FindFishStock <- isa12sf$FishStock
isa12sf[isa12sf$FindFishStock %in% drop_stock_f, "FindFishStock"] <- as.character(NA)
isa12sf$BindFishStock <- isa12sf$FishStock
isa12sf[isa12sf$BindFishStock %in% drop_stock_b, "BindFishStock"] <- as.character(NA)
isa12sf$FpaindFishStock <- isa12sf$FishStock
isa12sf[isa12sf$FpaindFishStock %in% drop_stock_fpa, "FpaindFishStock"] <-
as.character(NA)
isa12sf$BpaindFishStock <- isa12sf$FishStock
isa12sf[isa12sf$BpaindFishStock %in% drop_stock_bpa, "BpaindFishStock"] <-
as.character(NA)

```

```

# Proportion of TACs that have at least one rectangle assessed by FindFishStock and
BindFishStock
outf <- aggregate(isa12sf$FindFishStock, by=list(isa12sf$TAC_id), function(x) {
  no_rect_ass_find <- sum(!is.na(x))
  assessed_find <- no_rect_ass_find > 1
  return(assessed_find)
})

outb <- aggregate(isa12sf$BindFishStock, by=list(isa12sf$TAC_id), function(x) {
  no_rect_ass_bind <- sum(!is.na(x))
  assessed_bind <- no_rect_ass_bind > 1
  return(assessed_bind)
})

outfpa <- aggregate(isa12sf$FpainedFishStock, by=list(isa12sf$TAC_id), function(x) {
  no_rect_ass_find <- sum(!is.na(x))
  assessed_find <- no_rect_ass_find > 1
  return(assessed_find)
})

outbpa <- aggregate(isa12sf$BpainedFishStock, by=list(isa12sf$TAC_id), function(x) {
  no_rect_ass_bind <- sum(!is.na(x))
  assessed_bind <- no_rect_ass_bind > 1
  return(assessed_bind)
})

coverage <- data.frame(
  No_stocks = c(length(find_stocks), length(bind_stocks), length(fpained_stocks),
length(bpained_stocks)),
  No_TACs = length(unique(isa12sf$TAC_id)),
  No_TACs_assessed = c(sum(outf$x), sum(outb$x), sum(outfpa$x),
sum(outbpa$x)),
  Frac_TACs_assessed = c(mean(outf$x), mean(outb$x), mean(outfpa$x),
mean(outbpa$x))
)
rownames(coverage) <- c("F_indicator", "B_indicator", "Fpa_indicator", "Bpa_indicator")

if (savecsv) write.csv(coverage, "NEA/results/coverage.csv")

# number of stocks for which MSYBtrigger==Bpa
#df0 <- transform(saeu, bb=Bpa/MSYBtrigger==1)
#length(unique(subset(df0, bb==TRUE)$FishStock))

#=====
# Exporting and saving
#=====

if (savecsv) write.csv(saeu, file="NEA/results/saeu.csv")
if (savedata) save.image("NEA/results/out_nea.RData")

```

14 ANNEX 3 – MEDITERRANEAN AND BLACK SEAS CODE

```
#=====
# Indicators (design based)
#=====
setwd("~/gitlab/2023-cfpindicators/MED/data/design-based")
library(ggplotFL)
data=read.csv("MEDstockDB2023.csv")
source("funs.R")
names(data)
data= data[data$Year>2002,]

summary(data$Year)
summary(data$Bref)

data$indB=data$SSB/data$Bref

vpy <- 2019:2021

data=projectStkStatus(data, vpy)

# I1-2
fInda <- cbind(getNoStks(data, "indF", function(x) sum(x>1)), indicator="F>Fmsy")
fIndb <- cbind(getNoStks(data, "indF", function(x) sum(x<=1)), indicator="F≤FMSY")

fIndab <- rbind(fInda, fIndb)

# plot
if (savegraph) png("figMEDI1-2.png", 1800, 1200, res=300)
ggplot(subset(fIndab, EcoRegion=='ALL'), aes(x=Year, y=N, fill=indicator)) +
  geom_area() +
  expand_limits(y=0) +
  #geom_point(aes(x=iniYear:fniYear, y=N[1:18])) +
  #geom_point(aes(x=fniYear, y=N[length(N)]), size=2) +
  ggtitle(expression(paste("N stocks > ", F[MSY], " and N stocks ≤ ", F[MSY]))) +
  ylab("No. of stocks") +
  xlab("") +
  ylim(c(0,60)) +
# sc +
# th +
  scale_fill_grey(start=0.3, end=0.7)
if (savegraph) dev.off()

# plot
if (savegraph) png("figMEDI1-2b.png", 2400, 1200, res=300)
ggplot(subset(fIndab, EcoRegion != 'ALL'), aes(x=Year, y=N, fill=indicator)) +
  geom_area() +
  facet_grid(.~EcoRegion) +
  ggtitle(expression(paste("N stocks > ", F[MSY], " and N stocks ≤ ", F[MSY]))) +
  ylab("No. of stocks") +
  xlab("") +
  ylim(0, 30) +
#sc +
#th +
```

```

scale_fill_grey(start=0.3, end=0.7)
if (savegraph) dev.off()

# table
if (savecsv) write.csv(reshape2::dcast(fInda, EcoRegion~Year, value.var='N'),
file="tabMEDI1.csv", row.names=FALSE)
if (savecsv) write.csv(reshape2::dcast(fIndb, EcoRegion~Year, value.var='N'),
file="tabMEDI2.csv", row.names=FALSE)

#plot
data$CFP <- !(data$indF > 1 | data$indB < 1)

data= data[complete.cases(data[, 10]),]

fInde <- cbind(getNoStks(data, "CFP", function(x) sum(!x, na.rm=TRUE)), indicator = "F>FMSY |
B<BMSY")
fIndf <- cbind(getNoStks(data, "CFP", function(x) sum(x, na.rm=TRUE)), indicator = "F≤FMSY &
B≥BMSY")

fIndef <- rbind(fInde, fIndf)

## plot
png("figMed1.png", 1800, 1200, res=300)
ggplot(subset(fIndef, EcoRegion=='ALL'), aes(x=Year, y=N, fill=indicator)) +
  geom_area() +
  expand_limits(y=0) +
  #geom_point(aes(x=iniYear:fInlYear, y=N[1:18])) +
  #geom_point(aes(x=fInlYear, y=N[length(N)]), size=2) +
  ggtitle(expression("N of stocks complying or not with CFP")) +
  ylab("No. of stocks") +
  xlab("") +
  ylim(c(0,20)) +
  #sc +
  #th +
  scale_fill_grey(start=0.3, end=0.7)
dev.off()

# plot
png("figMed2.png", 2400, 1200, res=300)
ggplot(subset(fIndef, EcoRegion != 'ALL'), aes(x=Year, y=N, fill=indicator)) +
  geom_area() +
  facet_grid(.~EcoRegion) +
  ggtitle(expression("N of stocks complying or not with CFP")) +
  ylab("No. of stocks") +
  xlab("") +
  #sc +
  ylim(0, 17) +
  #th +
  scale_fill_grey(start=0.3, end=0.7)
dev.off()

write.csv(reshape2::dcast(fInde, EcoRegion~Year, value.var='N'), file="tabMED1.csv",
row.names=FALSE)
write.csv(reshape2::dcast(fIndf, EcoRegion~Year, value.var='N'), file="tabMED2.csv",
row.names=FALSE)

setwd("~/gitlab/2023-cfpindicators")

```

```

source('C:/Users/kupscsv/Documents/R/AssessmentEWGs/CFP/MEDanalysis/AlesMEDCFPfunctions.R')
source('MED/script/AlesMEDCFPfunctions.R')

#####
#####
# AM(20201121)
# MED indicators
#####
#####

library(ggplot2)
library(lme4)
library(influence.ME)
library(lattice)
library(parallel)
library(rgdal)
library(reshape2)
library(plyr)
library(doParallel)

#=====
# Setup
#=====

# year when assessments were performed

# assessmentYear <- as.numeric(substr(Sys.time(), start = 1, stop = 4))
assessmentYear <- 2023
# final year with estimations from stock assessments
fnyYear <- assessmentYear - 2
# initial year with estimations from stock assessments
iniYear <- 2003
# vector of years
dy <- iniYear:fnyYear
# vector of years for valid assessments
vay <- (assessmentYear-2):assessmentYear
# vector of years for stock status projection
vpy <- (fnyYear-2):fnyYear
# options for reading data
options(stringsAsFactors=FALSE)
# number of simulations for mle bootstrap
it <- 500
# number of cores for mle bootstrap parallel
nc <- 11
# quantiles to be computed
qtl <- c(0.025, 0.25, 0.50, 0.75, 0.975)
# to control de seed in mclapply
RNGkind("L'Ecuyer-CMRG")
set.seed(1234)
# to make plots consistent
vp <- dy
#vp[c(2,4,6,8,10,12,14,16)] <- ""
theme_set(theme_bw())

sc <- scale_x_continuous(breaks=seq(iniYear,fnyYear,2),
labels=as.character(seq(iniYear,fnyYear,2)))

```

```

th <- theme(axis.text.y = element_text(angle=0, vjust=0.5), axis.text.x =
element_text(angle=45, vjust=0.5), panel.grid.minor = element_blank())

#set
cl <- makeCluster(parallel::detectCores())
registerDoParallel(cl[1:(length(cl)-1)])

#=====
# load & pre-process
#=====

# load and pre-process #####
#
# gfcf <- read.csv('C:/Users/kupscsv/Documents/R/AssessmentEWGs/CFP/GFCMExtracted/GFCM_CFP_202
3_AND.csv') #removed Pil_3 and Mut_12_13_14 from the file because no EU fleets
gfcf <- read.csv('MED/data/GFCM_CFP_2023_AND.csv')
gfcf <- gfcf[gfcf$key!="PIL_3",]
gfcf <- gfcf[gfcf$key!="MUT_12_13_14",]

gfcf$Meeting <- "GFCM"
#
# stecf <- read.csv('C:/Users/kupscsv/Documents/R/AssessmentEWGs/CFP/STECFExtracted/STECF_CFP202
3_AND.csv')
stecf <- read.csv('MED/data/STECF_CFP2023_AND.csv')

#remove some duplicates from file 'GFCM_CFP_2022.csv' and ones that should not have been
downloaded
cat("#####Check for duplicate / GSA over lapping stocks",'\n')
cat(sort(c(paste(unique(gfcf$key),"G",sep="_"),paste(unique(stecf$key),"S",sep="_"))),sep='\n
')
cat("#####and remove manually",'\n')

msa <- rbind(stecf, gfcf)
msa$Fref <- msa$Fref_point
msa$Bref <- ifelse(msa$Bref=="Bmsy",msa$Bref_point, NA)
# id assessment source
msa[msa$Meeting!="GFCM","Meeting"] <- "STECF"
names(msa)[names(msa)=="Meeting"] <- "source"
names(msa)[names(msa)=="key"] <- "stk"

final_year <- tapply(msa$Year, list(msa$stk), max)
DataTable <- unique(msa[,c("EcoRegion","stk","Species","asses_year","source")])
DataTable$udated_stk <- NA
DataTable$new_stk <- NA
DataTable$description <- paste(DataTable$Species, 'in GSA', gsub('_',',',
',substring(DataTable$key,5,nchar(DataTable$key))))
write.csv(cbind.data.frame(DataTable,
final_year=final_year[DataTable$stk])[order(DataTable$EcoRegion,DataTable$stk),c('EcoRegion',
asses_year','stk','description','udated_stk','new_stk','source')], "MED/results/datasummary.csv")

# keep relevant columns only
msa <- msa[,c("Stock", "Area", "Year", "R", "SSB", "F", "Fref", "Blim", "Bref", "asses_year",
"source", "Assessment_URL", "Species", "EcoRegion")]

```

```

listEcoReg
setNames(as.data.frame(table(substring(unique(paste0(msa$Stock,msa$EcoRegion)),4))),c("Eco
Reg","Freq"))
toremove <- NULL #as.character(listEcoReg[listEcoReg$Freq<4,]$EcoReg)

#-----
# recode and compute indicators
#-----
msa$stk <- tolower(paste(msa$Stock, msa$Area, sep="_"))
msa$StockDescription <- paste(msa$Species, "in GSA", gsub("_", " ", msa$Area))
msa$Fref <- as.numeric(msa$Fref)
msa <- transform(msa, indF = F/Fref)
msa <- transform(msa, sfFind=!is.na(indF), i1=indF>1, i2=indF<=1)
names(msa)
#msa <- msa[!msa$Stock%in%"SOL",]
#-----
# subset
# (filtering through the sampling frame done during data harvesting)
#-----
sam <- msa[msa$Year >=iniYear & msa$Year <= fnlYear & msa$asses_year %in% vay,]

#-----
# project stock status
# (check fnlYear < assessmentYear-1)
#-----
sam$projected <- FALSE

# use y-2 for stocks missing in y-1
sy2 <- sam[sam$Year==sort(vpy)[1], "stk"]
sy1 <- sam[sam$Year==sort(vpy)[2], "stk"]
v0 <- sy2[!(sy2 %in% sy1)]
if(length(v0)>0){
  df0 <- subset(sam, Year==sort(vpy)[1] & stk %in% v0)
  df0$Year <- sort(vpy)[2]
  df0$projected <- TRUE
  df0$F <- df0$F+0.002
  sam <- rbind(sam, df0)
}

# use y-1 for stocks missing in y
sy <- sam[sam$Year==sort(vpy)[3], "stk"]
v0 <- sy1[!(sy1 %in% sy)]
if(length(v0)>0){
  df0 <- subset(sam, Year==sort(vpy)[2] & stk %in% v0)
  df0$Year <- sort(vpy)[3]
  df0$projected <- TRUE
  df0$F <- df0$F+0.005
  sam <- rbind(sam, df0)
}

#get summaries for last years stocks
#oldCFP
rbind.data.frame(read.csv('C:/Users/kupscsv/Documents/R/AssessmentEWGs/CFP/GFCM_CFP_20
22.csv'),
#
read.csv('C:/Users/kupscsv/Documents/R/AssessmentEWGs/CFP/STECF_CFP_2022.csv'))

```

```

oldCFP <- rbind.data.frame(read.csv('~/.gitlab/2022-
cfpindicators/data/med/GFCM_CFP_2022.csv'),
read.csv('~/.gitlab/2022-cfpindicators/data/med/STECF_CFP_2022.csv'))

added <- unique(paste(sam$Stock, sam$Area, sep=""))[!(unique(paste(sam$Stock, sam$Area,
sep="")) %in% unique(paste(oldCFP$Stock, oldCFP$Area, sep="")))]
dropped <- unique(paste(oldCFP$Stock, oldCFP$Area, sep=""))[!(unique(paste(oldCFP$Stock,
oldCFP$Area, sep="")) %in% unique(paste(sam$Stock, sam$Area, sep="")))]
consistency <-
c('dps_1','ara_5','ara_18_19_20','mut_19','ars_18_19_20','nep_5','nep_15_16','mur_15_16','ane
_7','ane_9','ane_16','ctc_17','eoi_18','mut_12_13_14','pil_3','pil_9','pil_16','pil_17_18','sbr_1_3','
mut_29','spr_29','whg_29','sba_25','mut_25','sol_17')
#sam2 <- sam[sam$stk %in% consistency == FALSE,]
#sam <- sam2 ; toremove <- as.character(listEcoReg[listEcoReg$Freq<4,]$EcoReg)
# write.csv(msa, paste("MEDstockDB", assessmentYear, ".csv", sep=""))

#=====
# Indicators
#=====
#-----
# Number of stocks (remove projected years)
#-----
df0 <- sam[!sam$projected,]
mnStks <- aggregate(stk~Year, df0, length)
names(mnStks) <- c("Year", "N")

# plot
png("MED/results/figMedI0.png", 1800, 1200, res=300)
ggplot(subset(mnStks, Year!=fmlYear), aes(x=Year, y=N)) +
  geom_line() +
  ylab("No. of stocks") +
  xlab("") +
  ylim(c(0,65)) +
  sc +
  th +
  geom_point(aes(x=fmlYear, y=mnStks$N[length(mnStks$N)]), size=2)
dev.off()

png("MED/results/figMedI0b.png", 1200, 1600, res=200)
df0 <- sam[!sam$projected,]
ggplot(df0, aes(Year,reorder(stk, desc(stk))))+
  geom_line() +
  geom_point(data=aggregate(list(Year=df0$Year, EcoRegion=df0$EcoRegion),
by=list(stk=df0$stk), max)) +
  ylab("") +
  theme(axis.text.y = element_text(angle = 180, vjust = 0.5, hjust=1))+
  xlab("Year") +
  sc +
  th +
  facet_grid(EcoRegion~., switch="y", space="free_y", scales="free_y") +
  theme(strip.text.y.left = element_text(angle=0))+
  theme(strip.placement="outside",
  #strip.background.y=element_blank(),
  strip.background =element_rect(fill="lightyellow"),
  panel.spacing.y=unit(0.05, "lines"))
dev.off()

```



```

write.csv(dcast(df0, EcoRegion~Year, value.var='stk', margins=TRUE, fun.aggregate=length),
file="MED/results/tabMedI0.csv", row.names=FALSE)

#-----
# drop final assessment year, redo scales for plotting
#-----
sam <- sam[sam$Year!=fnlYear,]

vp <- iniYear:I(fnlYear-1)
vp[c(2,4,6,8,10,12,14,16)] <- ""
sc <- scale_x_continuous(breaks=iniYear:I(fnlYear-1), labels=as.character(vp))

#-----
# (I7) F/Fmsy model based indicator
#-----
df0 <- sam[is.na(sam$indF)==FALSE,]

df0$Year <- factor(df0$Year)
yrs <- levels(df0$Year)
nd <- data.frame(Year=factor(yrs))
No <- length(unique(df0$stk))

# model
mfit <- glmer(indF ~ Year + (1|stk), data = df0, family = Gamma("log"),
control=glmerControl(optimizer="bobyqa"))#glmerControl(optimizer="nlminbwrap"))
runDiagsME(mfit, "stk", df0, "MED/results/diagMedI7.pdf", nc, nd)
getME(mfit,"theta")
getME(mfit,"lower")

# bootstrap
set.seed(1234)
stk <- unique(df0$stk)

system.time(
mfit.bsf <- foreach(sim=1:it) %dopar% {
  library(lme4)
  stk1 <- sample(stk, replace=TRUE)
  df1 <- df0[0,]
  for(i in stk1) df1 <- rbind(df1, subset(df0, stk==i))
  fit <- glmer(indF ~ Year + (1|stk), data = df1, family = Gamma("log"),
control=glmerControl(optimizer="nlminbwrap"))
  v0 <- predict(fit, re.form=~0, type="response", newdata=nd)
  if(length(fit@optinfo$conv$lme4)>0) v0[] <- NA
  v0
}
)

mfitm <- do.call("rbind", mfit.bsf)
cat('#####', sum(is.na(apply(mfitm,1,sum))), 'simulations did not converge')
mfitq <- apply(mfitm, 2, quantile, c(0.025, 0.25, 0.50, 0.75, 0.975), na.rm=TRUE)
mfitq <- cbind(Year=as.numeric(yrs), as.data.frame(t(mfitq)))

# plot
png("MED/results/figMedI7.png", 1800, 1200, res=300)
ggplot(mfitq, aes(x=Year)) +
  geom_ribbon(aes(ymin = `2.5%`, ymax = `97.5%`), fill="gray", alpha=0.60) +

```

```

geom_ribbon(aes(ymin = `25%`, ymax = `75%`), fill="gray", alpha=0.95) +
geom_line(aes(y=`50%`)) +
expand_limits(y=0) +
geom_point(aes(x=Year[length(Year)], y=`50%`[length(`50%`)]), size=2) +
geom_hline(yintercept = 1, linetype=2) +
ylab(expression(F/F[MSY])) +
xlab("") +
theme(legend.position = "none") +
sc +
th
dev.off()

# table
tb0 <- t(mfitq)[-1,]
colnames(tb0) <- mfitq[,1]
write.csv(tb0, file="MED/results/tabMedI7.csv")

#-----
# (I7b) F/Fmsy model regional
#-----
df0 <- sam
df0$Year <- factor(df0$Year)
yrs <- levels(df0$Year)
nd <- data.frame(Year=factor(yrs))

# remove Eastern Med. where only 2 stocks are available
df0 <- df0[!df0$EcoRegion%in%toremove,]

# df0 <- df0[df0$EcoRegion!=c("Eastern Med."),]
# df0 <- df0[df0$EcoRegion!=c("Black Sea"),]
mfitRegional <- lapply(split(df0, df0$EcoRegion), function(x){
  # fit model
  mfit <- glmer(indF ~ Year + (1|stk), data = x, family = Gamma("log"),
control=glmerControl(optimizer="nlminbwrap"))
  # no variance with bootstrap due to small number of stocks
  mfit.pred <- predict(mfit, re.form=~0, type="response", newdata=nd)
  # output
  list(mfit=mfit, mfit.pred=mfit.pred)
})

# naming including No of stocks
No <- lapply(split(df0, df0$EcoRegion), function(x) length(unique(x$stk)))
names(mfitRegional) <- paste(names(No), " (", No, ")", sep="")

lst0 <- lapply(mfitRegional, "[", "mfit.pred")
fIndfr <- data.frame(EcoRegion=rep(names(lst0), lapply(lst0, length)), N=unlist(lst0),
Year=as.numeric(as.character(nd[,1])))

# plot
png("MED/results/figMedI7b.png", 2400, 1200, res=300)
ggplot(fIndfr, aes(x=Year, y=N)) +
  geom_line() +
  facet_grid(.~EcoRegion) +
  geom_hline(yintercept = 1, linetype=2) +
  ylab(expression(F/F[MSY])) +
  xlab("") +
  sc +
  ylim(0, 4.5) +
  th

```

```

dev.off()

# table
write.csv(reshape2::dcast(fIndfr, EcoRegion~Year, value.var='N'),
file="MED/results/tabMedI7b.csv", row.names=FALSE)

#-----
# (I8) SSB indicator
#-----
# model

idx <- !is.na(sam$SSB)
df0 <- sam[idx,]
df0$Year <- factor(df0$Year)
yrs <- levels(df0$Year)
nd <- data.frame(Year=factor(yrs))
No <- length(unique(df0$stk))

# model
mfitb <- glmer(SSB ~ factor(Year) + (1|stk), data = df0, family = Gamma("log"),
control=glmerControl(optimizer="bobyqa"))#glmerControl(optimizer="nlminbwrap"))
runDiagsME(mfitb, "stk", df0, "MED/results/diagMedI8.pdf", nc, nd)

# bootstrap
set.seed(1234)
stk <- unique(df0$stk)
system.time(
  mfit.bs2003 <- foreach(sim=1:it) %dopar% {
    library(lme4)
    stk1 <- sample(stk, replace=TRUE)
    df1 <- df0[0,]
    for(i in stk1) df1 <- rbind(df1, subset(df0, stk1==i))
    fit <- glmer(SSB ~ Year + (1|stk), data = df1, family = Gamma("log"),
control=glmerControl(optimizer="nlminbwrap"))#glmerControl(optimizer="nlminbwrap"))
    v0 <- predict(fit, re.form=~0, type="response", newdata=nd)
    if(length(fit@optinfo$conv$lme4)>0) v0[] <- NA
    v0
  }
)

mfitm <- do.call("rbind", mfit.bs2003)
mfitm <- exp(log(mfitm)-mean(log(mfitm[,1]), na.rm=TRUE))
mfitq <- apply(mfitm, 2, quantile, c(0.025, 0.25, 0.50, 0.75, 0.975), na.rm=TRUE)
mfitq <- cbind(Year=as.numeric(yrs), as.data.frame(t(mfitq)))

# plot
png("MED/results/figMedI8-with-2-noneu-stocks.png", 1800, 1200, res=300)
ggplot(mfitq, aes(x=Year)) +
  geom_ribbon(aes(ymin = `2.5%`, ymax = `97.5%`), fill="gray", alpha=0.60) +
  geom_ribbon(aes(ymin = `25%`, ymax = `75%`), fill="gray", alpha=0.95) +
  geom_line(aes(y=`50%`)) +
  expand_limits(y=0) +
  geom_point(aes(x=Year[length(Year)], y=`50%`[length(`50%`)]), size=2) +
  geom_hline(yintercept = 1, linetype=2) +
  ylab(expression(B/B[2003])) +
  xlab("") +
  theme(legend.position = "none") +
  sc +
  th

```

```

dev.off()

tb0 <- t(mfitq)[-1,]
colnames(tb0) <- mfitq[,1]
write.csv(tb0, file="MED/results/tabMedI8.csv")

if (savegraph) png("EUW/results/FFmsyMED_stock_single.png", 1000, 600)
ggplot(data=df0[df0$stk!="pil_17_18" & df0$stk!="spr_29",], aes(x=Year, y=SSB, group=stk)) +
  geom_line(aes(color=stk)) +
  xlab("Years")+
  ylab("SSB")+
  theme(legend.position = "right") +
  labs(color = "Stock Code")+
  ggtitle("SSB")
if (savegraph) dev.off()

test <- df0
test$SSB <- test$SSB / mean(test[test$Year=="2003","SSB"])

ggplot(data=test, aes(x=Year, y=SSB, group=stk)) +
  geom_line(aes(color=stk)) +
  xlab("Years")+
  ylab("SSB")+
  theme(legend.position = "right") +
  labs(color = "Stock Code")+
  ggtitle("SSB")

#for (i in unique(test$stk))
#test[test$stk==i,"SSB"] <- test[test$stk==i,"SSB"]/ test[test$stk==i
#test$Year==as.factor(2003),"SSB"] &

#-----
# (I8) SSB indicator 2, rel(B/BMSY)
#-----

# estimate Biomass directly first
#-----
df0 <- sam[!is.na(sam$Bref),]
df0$Year <- factor(df0$Year)
yrs <- levels(df0$Year)
nd <- data.frame(Year=factor(yrs))
No <- length(unique(df0$stk))
#Bmsys <- unique(df0$Bref)

# model
mfitb <- glmer(SSB ~ factor(Year) + (1|stk), data = df0, family = Gamma("log"),
control=glmerControl(optimizer="nlminbwrap"))
runDiagsME(mfitb, "stk", df0, "diagMedI8abs.pdf", nc, nd)

# bootstrap
set.seed(1234)
stk <- unique(df0$stk)
system.time(
mfit.bsab <- foreach(sim=1:it) %dopar% {
  library(lme4)
  stk1 <- sample(stk, replace=TRUE)

```

```

df1 <- df0[0,]
for(i in stk1) df1 <- rbind(df1, subset(df0, stk1==i))
fit <- glmer(SSB ~ Year + (1|stk), data = df1, family = Gamma("log"),
control=glmerControl(optimizer="nlminbwrap"))
v0 <- predict(fit, re.form=~0, type="response", newdata=nd)
if(length(fit@optinfo$conv$lme4)>0) v0[] <- NA
v0
}
)

mfitm <- do.call("rbind", mfit.bsab)
mfitm <- exp(log(mfitm)-mean(log(df0$Bref), na.rm=TRUE))
mfitq <- apply(mfitm, 2, quantile, c(0.025, 0.25, 0.50, 0.75, 0.975), na.rm=TRUE)
mfitq <- cbind(Year=as.numeric(yrs), as.data.frame(t(mfitq)))

# plot
png("figMedI8ab.png", 1800, 1200, res=300)
ggplot(mfitq, aes(x=Year)) +
  geom_ribbon(aes(ymin = `2.5%`, ymax = `97.5%`), fill="gray", alpha=0.60) +
  geom_ribbon(aes(ymin = `25%`, ymax = `75%`), fill="gray", alpha=0.95) +
  geom_line(aes(y=`50%`)) +
  expand_limits(y=0) +
  geom_point(aes(x=Year[length(Year)], y=`50%`[length(`50%`)]), size=2) +
  geom_hline(yintercept = 1, linetype=2) +
  ylab(expression(B/Bmsy)) +
  xlab("") +
  theme(legend.position = "none") +
  sc +
  th
dev.off()

tb0 <- t(mfitq)[-1,]
colnames(tb0) <- mfitq[,1]
write.csv(tb0, file="tabMedI8abs.csv")

#estimate SSB ratio indicator
#-----

df0 <- sam[!is.na(df0$Bref),]
df0$relB <- df0$SSB/df0$Bref
df0$Year <- factor(df0$Year)
yrs <- levels(df0$Year)
nd <- data.frame(Year=factor(yrs))
No <- length(unique(df0$stk))

# model
mfitb <- glmer(relB ~ factor(Year) + (1|stk), data = df0, family = Gamma("log"),
control=glmerControl(optimizer="nlminbwrap"))
runDiagsME(mfitb, "stk", df0, "diagMedI8rel.pdf", nc, nd)

# bootstrap
set.seed(1234)
stk <- unique(df0$stk)
system.time(
mfit.bsrel <- foreach(sim=1:it) %dopar% {
  library(lme4)
  stk1 <- sample(stk, replace=TRUE)
  df1 <- df0[0,]

```

```

for(i in stk1) df1 <- rbind(df1, subset(df0, stk1==i))
fit <- glmer(relB ~ Year + (1|stk), data = df1, family = Gamma("log"),
control=glmerControl(optimizer="nlminbwrap"))
v0 <- predict(fit, re.form=~0, type="response", newdata=nd)
if(length(fit@optinfo$conv$lme4)>0) v0[] <- NA
v0
}
)

mfitm <- do.call("rbind", mfit.bsrel)
mfitq <- apply(mfitm, 2, quantile, c(0.025, 0.25, 0.50, 0.75, 0.975), na.rm=TRUE)
mfitq <- cbind(Year=as.numeric(ysrs), as.data.frame(t(mfitq)))

# plot
png("figMedI8rel.png", 1800, 1200, res=300)
ggplot(mfitq, aes(x=Year)) +
  geom_ribbon(aes(ymin = `2.5%`, ymax = `97.5%`), fill="gray", alpha=0.60) +
  geom_ribbon(aes(ymin = `25%`, ymax = `75%`), fill="gray", alpha=0.95) +
  geom_line(aes(y=`50%`)) +
  expand_limits(y=0) +
  geom_point(aes(x=Year[length(Year)], y=`50%`[length(`50%`)]), size=2) +
  geom_hline(yintercept = 1, linetype=2) +
  ylab(expression(B/Bmsy)) +
  xlab("") +
  theme(legend.position = "none") +
  sc +
  th
dev.off()

tb0 <- t(mfitq)[-1,]
colnames(tb0) <- mfitq[,1]
write.csv(tb0, file="tabMedI8rel.csv")

#-----
# (I8) SSB indicator regional
#-----
idx <- !is.na(sam$SSB)
df0 <- sam[idx,]
df0$Year <- factor(df0$Year)
ysrs <- levels(df0$Year)
nd <- data.frame(Year=factor(ysrs))
# remove Eastern Med. where only 2 stocks are available
df0 <- df0[!df0$EcoRegion%in%toremove,]
# df0 <- df0[df0$EcoRegion!="Eastern Med.",]
# df0 <- df0[df0$EcoRegion!="Black Sea",]
mfitbRegional <- lapply(split(df0, df0$EcoRegion), function(x){
  # fit model
  mfitb <- glmer(SSB ~ factor(Year) + (1|stk), data = x, family = Gamma("log"),
control=glmerControl(optimizer="nlminbwrap"))
  # no variance with bootstrap due to small number of stocks
  mfitb.pred <- predict(mfitb, re.form=~0, type="response", newdata=nd)
  # output
  list(mfitb=mfitb, mfitb.pred=mfitb.pred/mfitb.pred[nd==iniYear])
})

# naming including No of stocks
No <- lapply(split(df0, df0$EcoRegion), function(x) length(unique(x$stk)))
names(mfitbRegional) <- paste(names(No), " (", No, ")", sep="")

```

```

lst0 <- lapply(mfitbRegional, "[", "mfitb.pred")
bIndfr <- data.frame(EcoRegion=rep(names(lst0), lapply(lst0, length)), N=unlist(lst0),
Year=as.numeric(as.character(nd[,1])))

# plot
png("figMedI8b.png", 2400, 1200, res=300)
ggplot(bIndfr, aes(x=Year, y=N)) +
  geom_line() +
  facet_grid(.~EcoRegion) +
  geom_hline(yintercept = 1, linetype=2) +
  ylab(expression(B/B[2003])) +
  xlab("") +
  sc +
  th
dev.off()

# table
write.csv(reshape2::dcast(bIndfr, EcoRegion~Year, value.var='N'), file="tabMedI8b.csv",
row.names=FALSE)
write.csv(sam, file="sam.csv")
#save.image("med.RData")

##### Coverage Indicator

```

15 ANNEX 4 – DESIGN BASED INDICATORS FOR THE MEDITERRANEAN AND BLACK SEAS

15.1 Number of stocks by year where fish mortality is above/below F_{MSY}

The number of stocks for which an F time series and an associated F_{MSY} were provided increased from 38 to 57 over the years 2003-2009 (Figure 32, Table 27 and Table 28). It then reached a plateau at 57 until 2020 and decreased to 53. The number of stocks that were not overfished ($F \leq F_{MSY}$) increased from 5 to 17 over the years 2003-2021. Larger number of stocks are assessed in ecoregions Western Med. and Central Med. than in Eastern Med. and Black Sea (Figure 33, Table 27 and Table 28). Western Med. and Central Med. are also the two ecoregions where the number of not overfished stocks has increased the most.

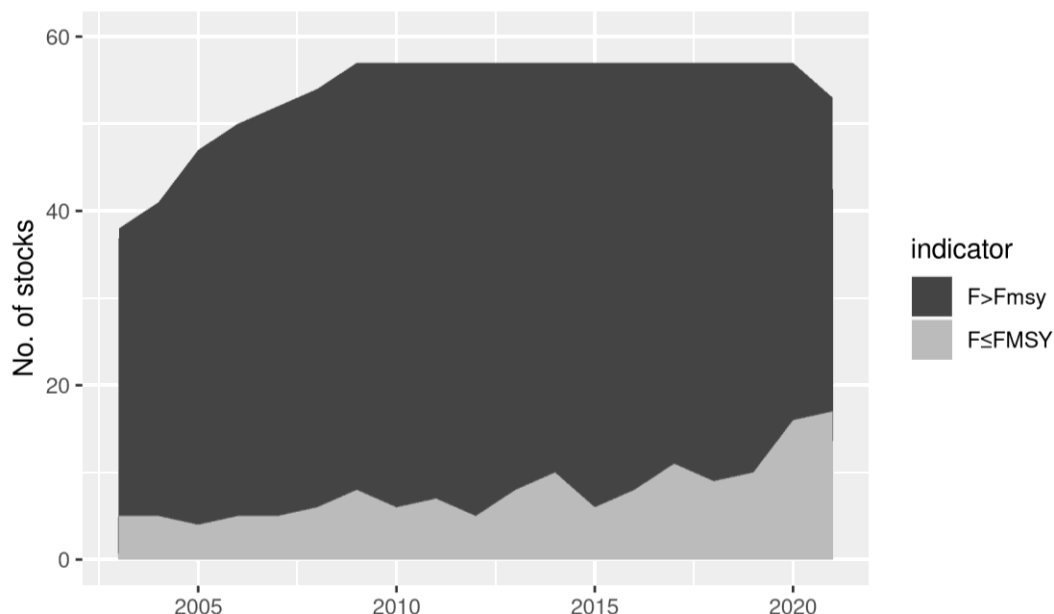


Figure 32: Number of stocks by year for which fishing mortality (F) was above/below F_{MSY} (MEDI1-2)

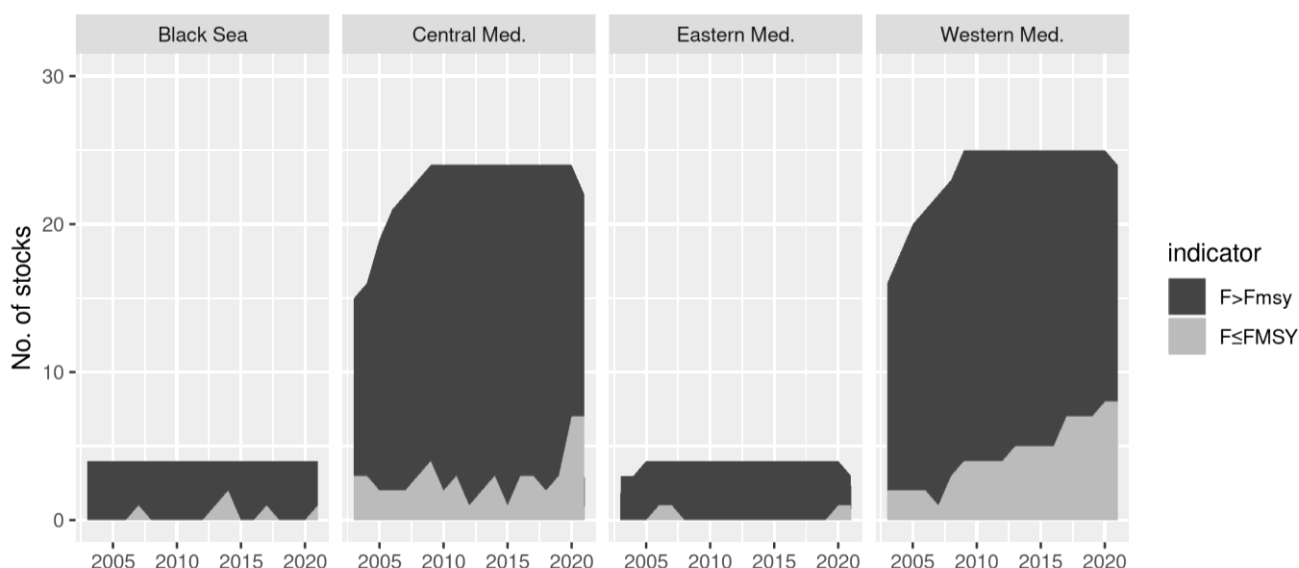


Figure 33: Number of stocks by ecoregion for which fishing mortality (F) was above/below F_{MSY} (MEDI1-2b)

Table 27: Number of stocks by ecoregion for which fishing mortality (F) exceeded F_{MSY} (MEDI2)

EcoRegion	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
ALL	33	36	43	45	47	48	49	51	50	52
Black Sea	4	4	4	4	3	4	4	4	4	4
Central Med.	12	13	17	19	20	20	20	22	21	23
Eastern Med.	3	3	4	3	3	4	4	4	4	4
Western Med.	14	16	18	19	21	20	21	21	21	21

EcoRegion	2013	2014	2015	2016	2017	2018	2019	2020	2021
ALL	49	47	51	49	46	48	47	41	36
Black Sea	3	2	4	4	3	4	4	4	3
Central Med.	22	21	23	21	21	22	21	17	15
Eastern Med.	4	4	4	4	4	4	4	3	2
Western Med.	20	20	20	20	18	18	18	17	16

Table 28: Number of stocks by ecoregion for which fishing mortality (F) did not exceed F_{MSY} (MEDI2)

EcoRegion	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
ALL	5	5	4	5	5	6	8	6	7	5
Black Sea	0	0	0	0	1	0	0	0	0	0
Central Med.	3	3	2	2	2	3	4	2	3	1
Eastern Med.	0	0	0	1	1	0	0	0	0	0
Western Med.	2	2	2	2	1	3	4	4	4	4

EcoRegion	2013	2014	2015	2016	2017	2018	2019	2020	2021
ALL	8	10	6	8	11	9	10	16	17
Black Sea	1	2	0	0	1	0	0	0	1
Central Med.	2	3	1	3	3	2	3	7	7
Eastern Med.	0	0	0	0	0	0	0	1	1
Western Med.	5	5	5	5	7	7	7	8	8

15.2 Number of stocks with $F > F_{MSY}$ or $B < B_{MSY}$ and $F \leq F_{MSY}$ or $B \geq B_{MSY}$

For the first time this year, B_{MSY} reference points were available for 16 Mediterranean stocks (Table 26), hence the design-based indicators 'Number of stocks with $F > F_{MSY}$ or $B < B_{MSY}$ and $F \leq F_{MSY}$ or $B \geq B_{MSY}$ ' were computed. This indicator is more reliable after 2008, when the number of stocks is stabilised. The results are summarised in Figure 34 and Figure 35 and Table 29 and Table 30.

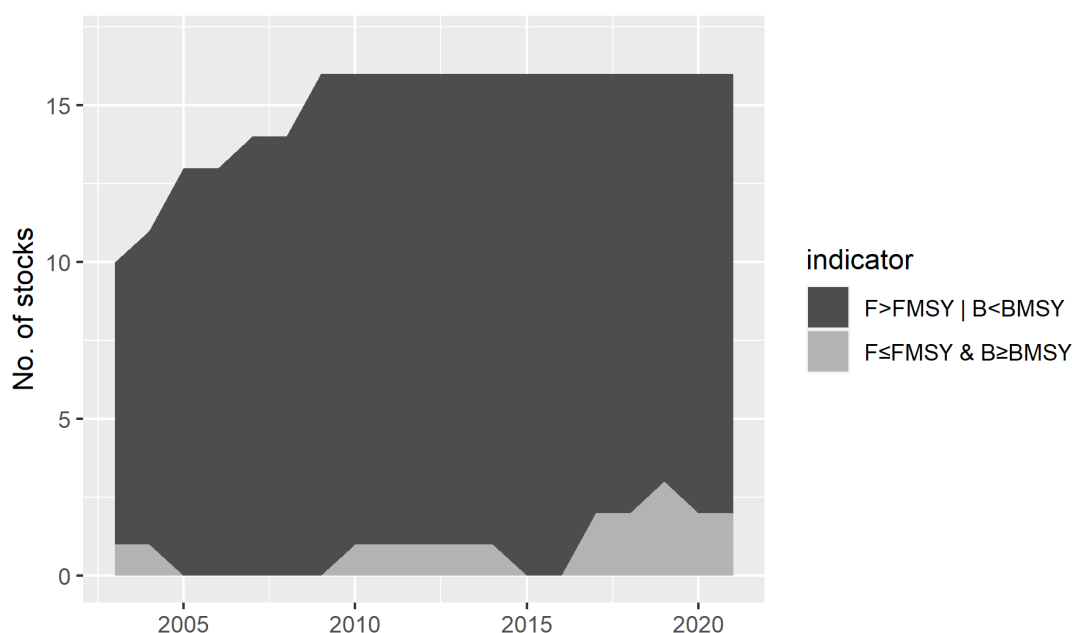


Figure 34: Number of stocks with $F > F_{MSY}$ or $SSB < B_{MSY}$ and number of stocks with $F \leq F_{MSY}$ and $SSB \geq B_{MSY}$ in the Mediterranean & Black Seas (MEDI5-6).

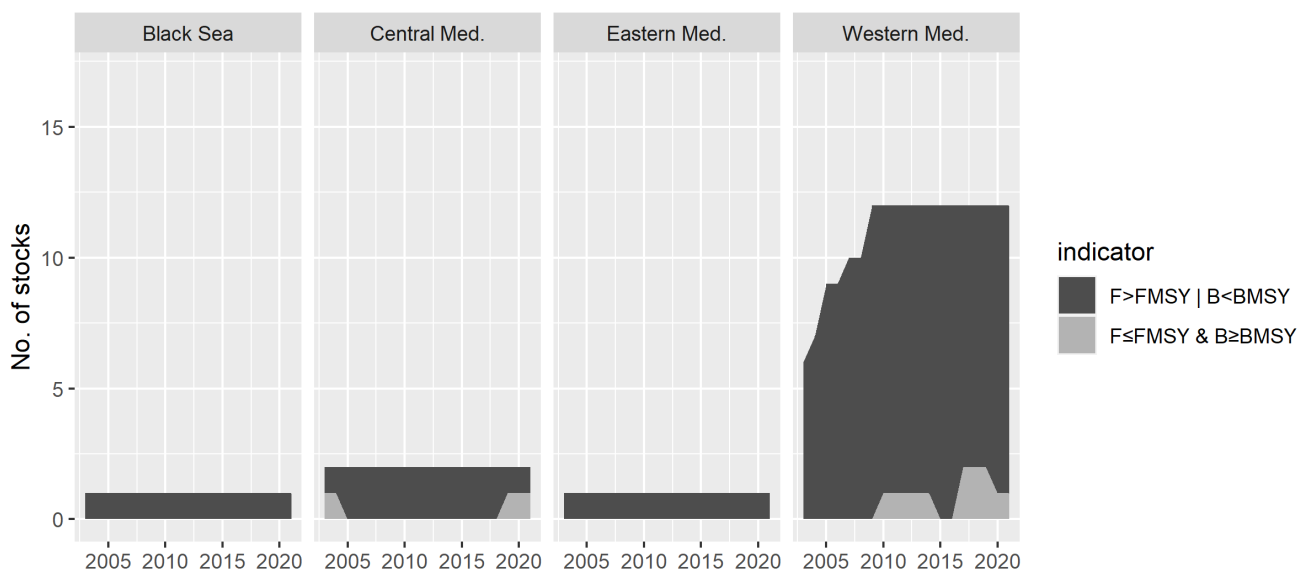


Figure 35: Number of stocks with $F > F_{MSY}$ or $SSB < B_{MSY}$ and number of stocks with $F \leq F_{MSY}$ and $SSB \geq B_{MSY}$ by ecoregion in the Mediterranean & Black Seas (MEDI5-6b).

Table 29: Number of stocks with $F > F_{MSY}$ or $SSB < B_{MSY}$ for the Mediterranean & Black Sea ecoregion (MEDI5)

EcoRegion	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
ALL	9	10	13	13	14	14	16	15	15	15
Black Sea	1	1	1	1	1	1	1	1	1	1
Central Med.	1	1	2	2	2	2	2	2	2	2
Eastern Med.	1	1	1	1	1	1	1	1	1	1
Western Med.	6	7	9	9	10	10	12	11	11	11

EcoRegion	2013	2014	2015	2016	2017	2018	2019	2020	2021
ALL	15	15	16	16	14	14	13	14	14
Black Sea	1	1	1	1	1	1	1	1	1
Central Med.	2	2	2	2	2	2	1	1	1
Eastern Med.	1	1	1	1	1	1	1	1	1
Western Med.	11	11	12	12	10	10	10	11	11

Table 30: Number of stocks with $F \leq F_{MSY}$ and $SSB \geq B_{MSY}$ for the Mediterranean & Black Sea ecoregion (MEDI6)

EcoRegion	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
ALL	1	1	0	0	0	0	0	1	1	1
Black Sea	0	0	0	0	0	0	0	0	0	0
Central Med.	1	1	0	0	0	0	0	0	0	0
Eastern Med.	0	0	0	0	0	0	0	0	0	0
Western Med.	0	0	0	0	0	0	0	1	1	1

EcoRegion	2013	2014	2015	2016	2017	2018	2019	2020	2021
ALL	1	1	0	0	2	2	3	2	2
Black Sea	0	0	0	0	0	0	0	0	0
Central Med.	0	0	0	0	0	0	1	1	1
Eastern Med.	0	0	0	0	0	0	0	0	0
Western Med.	1	1	0	0	2	2	2	1	1

16 ANNEX 5 – SENSITIVITY ANALYSES

16.1 Sensitivity analysis of the indicator F/F_{MSY} for NEA EU waters

In the assessment years 2021 and 2022, ICES accepted stocks assessed by Bayesian Biomass Dynamic Models (BDM) as category 1 or 2 assessments. In this sensitivity analysis, the model-based indicator F/F_{MSY} for NEA EU waters was run after removing all the stocks that were assessed with a BDM. Those stocks were lez.27.4a6a, lez.27.6b, nep.fu.25, nep.fu.2627, nep.fu.31, ple.27.24-32, por.27.nea, rju.27.7de. The results (Figure 36) showed that the median followed the same trend but had a different scale compared to the indicator presented in Figure 9. When the BDM were removed from the dataset, the median decreased <1 in 2020 instead of 2012.

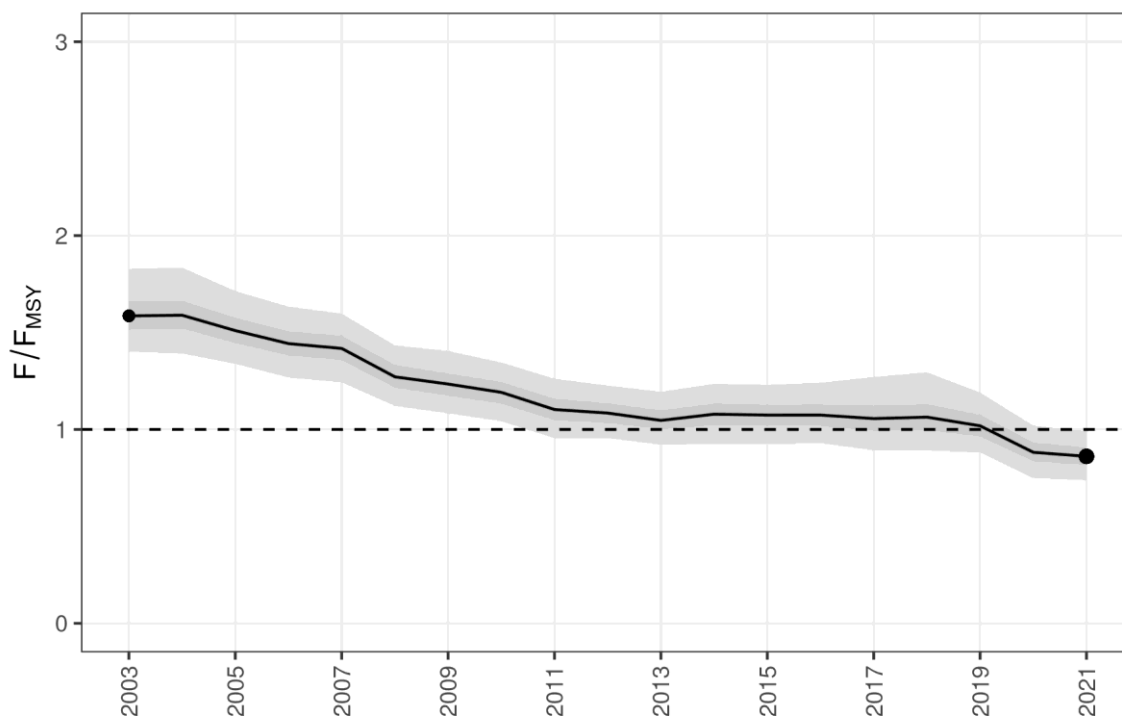


Figure 36: Trend in F/F_{MSY} (based on 49 stocks) for a dataset excluding all the Bayesian biomass dynamic models. Dark grey zone shows the 50% confidence interval whereas the light grey zone shows the 95% confidence interval.

An additional sensitivity analysis was done by running the model without ple.27.24-32, por.27.nea, rju.27.7de. The removal of these stocks did not change the trend. The only noticeable impact was seen on the scale (Figure 37). The median decreased <1 in 2013 and remained in the close vicinity of 1 until 2019.

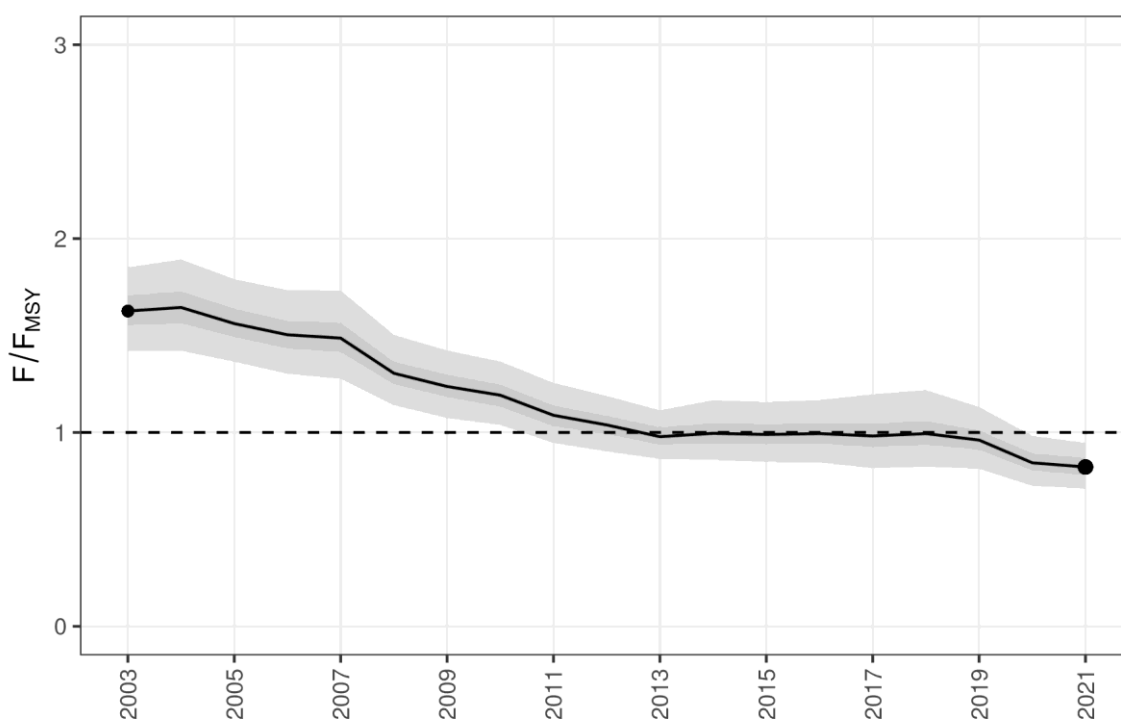


Figure 37: Trend in F/F_{MSY} (based on 54 stocks) for a dataset excluding ple.27.24-32, por.27.nea and rju.27.7de Bayesian biomass dynamic models. Dark grey zone shows the 50% confidence interval whereas the light grey zone shows the 95% confidence interval.

16.2 Sensitivity analysis of the indicator F/F_{MSY} for NEA non-EU waters

The indicator F/F_{MSY} for the NEA non-EU is fitted using a dataset of 17 stocks. One of these stocks, pra.27.1-2 was fished significantly below F_{MSY} . Figure 38, compared to Figure 11 showed that including pra.27.1-2 does not affect the trend of the indicator but affects its scale.

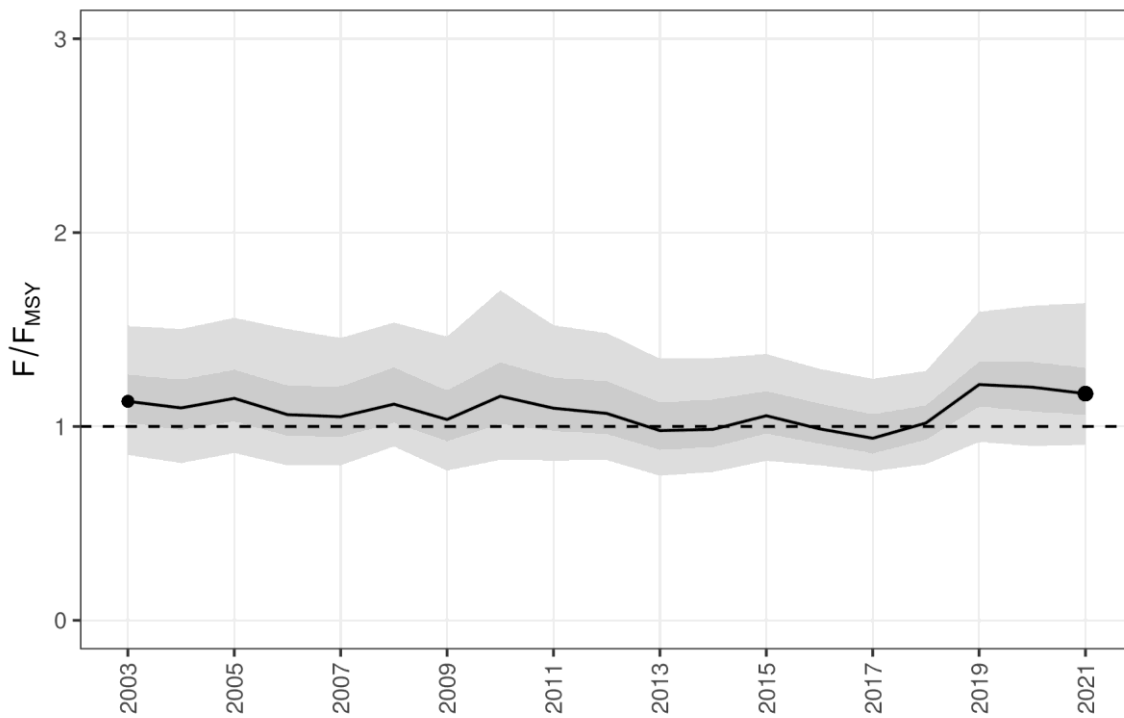


Figure 38: Trend in F/F_{MSY} for NEA stocks outside EU waters (based on 17 stocks including pra.27.1-2). Dark grey zone shows the 50% confidence interval whereas the light grey zone shows the 95% confidence interval.

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