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Protocol for the Monitoring of the Common Fisheries Policy

(Version 5.0)

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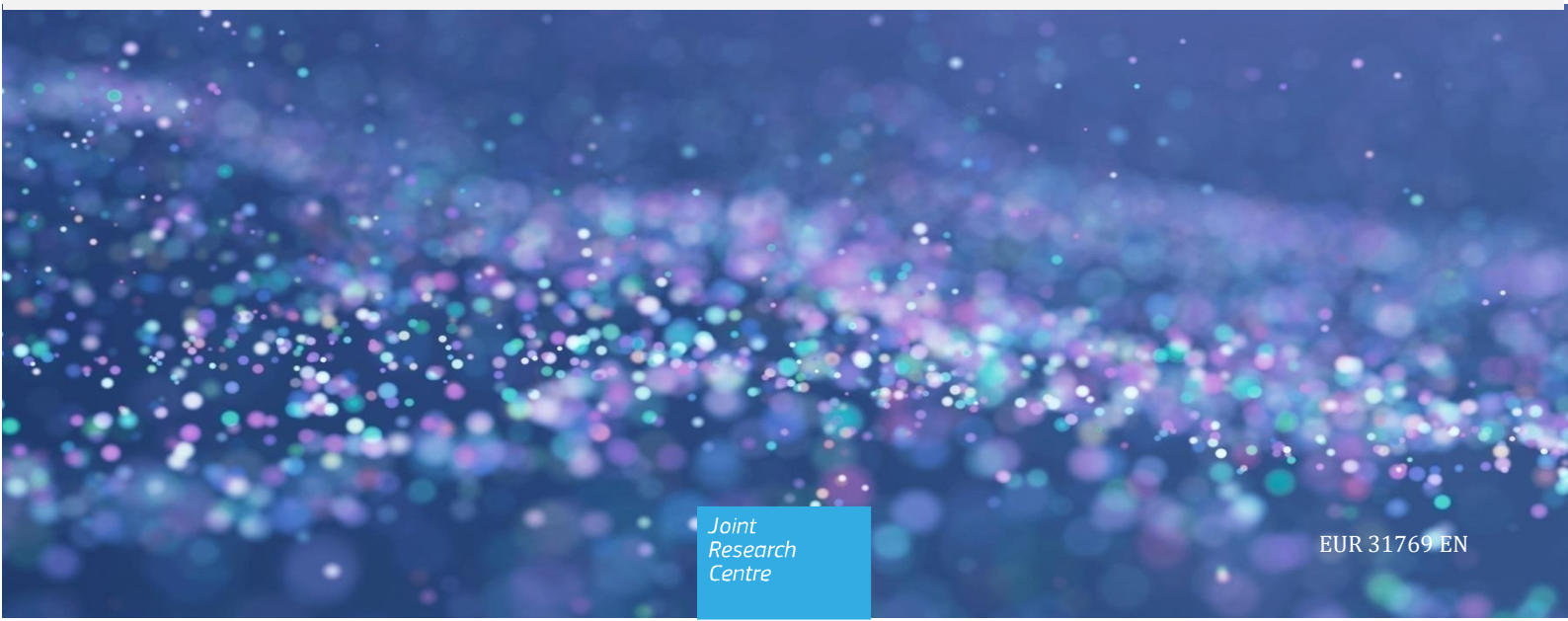

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Contents

Abstract

Monitoring the performance of the Common Fisheries Policy (CFP) is required by Article 50 of the CFP. The European Commission requests the Scientific Technical Economic Committee for Fisheries (STECF) to report on this performance every year. To ensure consistency of the indicators over time, this protocol was developed by JRC experts and approved by STECF. The protocol defines the geographical scope of the analysis as FAO area 27 (northeast Atlantic, NEA) and FAO area 37 (Mediterranean and Black Sea, MED). The data should be sourced from the International Council for the Exploration of the Sea (ICES), the General Fisheries Commission for the Mediterranean (GFCM) and the Scientific Technical Economic Committee for Fisheries (STECF). To identify the list of stocks that will be retained in the analysis, a sampling frame is used to filter all stocks managed with a TAC in the NEA and all stocks with a quantitative assessment from the relevant GSAs in the MED. Three types of indicators of management performance are used. First, the number of "fit for purpose" data provides an overview of the available stocks used in the report. Second, the design-based indicators provide the number of stocks that are above/below different reference points in relation to fishing pressure, safe biological limits and Maximum Sustainable Yield (MSY) limits. Third, the model-based indicators provide trends in exploitation, biomass and decadal recruitment. For model-based indicators, the data are modelled using a state-space model as implemented in the R-package JARA. The model specification is detailed in this protocol. A series of indicators of advice coverage is also defined.

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Executive summary

The Common Fisheries Policy (CFP, Reg (EU) 1380/2013) regulates fishing activity in EU waters. One of the main objectives of the CFP is to achieve maximum sustainable yield (MSY) for the exploited stocks. Article 50 of the CFP states that "The Commission shall report 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".

Although the monitoring should cover all the fishing areas where EU-flagged vessels operate, it was decided based on data availability to include stocks from the FAO area 27 (northeast Atlantic, NEA) and the FAO area 37 (Mediterranean and Black Sea, MED). Three geographical levels are considered in the analysis: the EU level, the sea basin level and the ecoregion level.

The data are sourced from the International Council for the Exploration of the Sea (ICES), the General Fisheries Commission for the Mediterranean (GFCM) and the Scientific Technical Economic Committee for Fisheries (STECF).

Assessments published by the bodies mentioned above in the 3 years preceding the monitoring year are considered to compute the indicators.

Only stocks with substantial catches by EU fleets are considered for the CFP monitoring indicators. Furthermore, in the NEA, a sampling frame is used to retain stocks that have a TAC and an assessment that can be used in the computation of indicators required in the analysis. In the MED, all stocks with appropriate quantitative stock assessments are retained.

Using the collected data, indicators of management performance and advice coverage are also computed.

The management performance is monitored using three sets of indicators: number of stocks with "fit for purpose" data, design-based and model-based. The first set provides the number of stocks with fishing pressure and associated reference point available for the analysis. Second, the design-based indicators track the number of stocks above/below thresholds in relation to exploitation at F_{MSY}, the number of stocks being inside/outside safe biological limits and the number of stocks being inside/outside MSY limits. Finally, model-based indicators provide trends in fishing pressure over its reference point, biomass and decadal recruitment. Model-based indicators are derived using a state-space model.

The advice coverage indicators provide the number of stocks for which estimates of F_{MSY}, $MSYB_{trigger}$, B_{PA} and B_{MSY} are provided as well as the fraction of TACs covered by stock assessment in the last assessment year.

Any new indicator should be presented in the annex of the report for evaluation by the STECF prior to being included in the core of the report, to validate its consistency over time.

Any change to the protocol should be approved by the STECF committee.

1 Introduction

The Common Fisheries Policy (CFP, Reg (EU) 1380/2013) regulates fishing activity in European Union waters. One of the main objectives of the CFP is to achieve Maximum Sustainable Yield (MSY) for the exploited stocks. Article 50 of the CFP states that "The Commission shall report 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".

The European Commission requests from the Scientific, Technical and Economic Committee for Fisheries (STECF) to report annually on the CFP implementation through the derivation and publication of a series of indicators.

To make the process as consistent as possible, the following set of rules was developed to be used as a guiding protocol for computing the required indicators. The rules also contribute to the transparency of the process. This protocol (version 5.0) is an update from the previous version (Jardim et al., 2019).

This protocol covers the three major elements of the process:

— Data issues: data sources, reference list of stocks, selection of stocks.

— 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 accessibility, the analysis will mainly focus on stocks with substantial exploitation by EU fleets in the FAO areas 27 (NEA: Northeast Atlantic and Adjacent Seas) and 37 (MED: Mediterranean and Black Sea). In the NEA, the core geographical scope shall entail ICES areas 3, 4 (excluding Norwegian waters of division 4a), 6, 7, 8, 9, and 10. In the MED, the core geographical scope shall entail GSAs 1, 2, 5, 6, 7, 8, 9, 10, 11, 15, 16, 17, 18, 19, 20, 22, 23, 25, and 29. Stocks straddling across the above mentioned and other adjacent areas not listed above are to be included. Including any other quantitative stock assessment outside the core geographical scope should be justified.

The analysis has three geographical levels: global EU level, sea basin level (NEA and MED), and ecoregion level. The ecoregions for which the indicators are computed (if more than 3 stocks) are the following:

— Baltic Sea (NEA)

— Greater North Sea (NEA)

— Celtic Seas (NEA)

— Bay of Biscay and the Iberian Coast (NEA)

— Azores (NEA)

— Widely distributed (NEA)

— Western Mediterranean (MED)

— Central Mediterranean (MED)

— Eastern Mediterranean (MED)

— Black Sea (MED)

All ecoregions correspond to the respective ICES Ecoregions, noting that 'Widely distributed' refers to stocks distributed over a wide range of NE Atlantic ecoregions, 'Central Mediterranean' refers to ICES Ecoregions 'Adriatic Sea' and 'Ionian Sea and the Central Mediterranean Sea' combined, and 'Eastern Mediterranean' corresponds to ICES Ecoregion 'Aegean-Levantine Sea'.

If not part of the 'Widely distributed', straddling stocks are allocated to the ecoregion where they are primarily distributed.

1.2 Definitions

— f or F represent fishing mortality as reported by scientific advice bodies;

— HR represents harvest rate, e.g. catch / biomass;

— b or B represent biomass, either as total stock biomass (TSB) or spawning stock biomass (SSB);

— 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 (e.g. $F_{0.1}$);

— 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...N stock index, where N is the total number of stocks selected for the analysis;
- t = 1...T year index, where T is the number of years in the reported time series;

— m = 1...M index of sampling units (a descriptor for a given geographical area covered by a TAC for a given species), where M is the total number of stocks in the reference list;

— d is the decadal recruitment which is derived for each year t_0 and stock j as $d_{jt_0} = \frac{\sum_{t=t_0}^{t=t_0-9} r_{jt}}{\sum_{t=t_0-10}^{t=t_0-19} r_{jt}}$;

— ∨ stands for "OR" in Boolean logic;

— ∧ stands for "AND" in Boolean logic;

— $\delta(\cdot)$ an indicator function such as $\delta(x) = \begin{cases} 1 & \text{if condition } x \text{ is fulfilled} \\ 0 & \text{otherwise} \end{cases}$

— $\exists X_j$ means that an estimation of X exists for stock j.

2 Data

2.1 Data sources

All indicators are computed using results from single stock quantitative stock assessments. Time series of estimates of fishing mortality, spawning stock biomass, recruitment and the accepted 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) or the Scientific Technical Economic Committee for Fisheries (STECF).

Results from surplus production models and delay-difference models, which are mostly reported as F or F/F_{MSY} are included in all the indicators if ICES stock is category 1 or 2 or if GFCM/STECF quantitative assessment. Outputs B and B_{MSY}, are included in the analysis, in the design-based indicators.

Results from catch-based models with tuning indices that estimate time-series of fishing mortality and/or spawning stock biomass are included in the analysis.

Results from methods that directly estimate total abundance and/or harvest rate (e.g. under-water TV camera) could be included in the analysis, for some indicators based on suitability.

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 also constitutes the basis 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 that are relevant to the ICES areas listed in the scope (section 1.1). A sampling frame is used to filter stocks that have a TAC from stocks that do not.

— Mediterranean and Black Sea (FAO area 37): the list of stocks comprises all stock assessments used for quantitative advice provided by the bodies listed in the data sources (section 2.1) that are relevant to the GSAs listed in the scope (section 1.1).

2.3 Selection of stock assessments

— The stock assessments selected are the ones carried out in the last three years before the CFP monitoring year using recent data, they are listed in the reference list and have at least 5 continuous years of estimates in the end of the time series.

— Exploratory assessments or assessments not yet approved by ICES, GFCM or STECF are not included;

— When several stocks are merged into 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.

For selected stocks of which the stock assessment results do not cover the recent period of evaluation, the most recent estimates available will be forecasted for a maximum of one year using the state-space model JARA.

3 Indicators of management performance

Three groups of indicators are used to monitor the performance of the CFP management regime, (i) the number of stocks with fit for purpose data, (ii) the design-based indicators that count the number of stocks above/below reference points and (iii) the model-based indicators that provide a modelling trend over time of fishing pressure, biomass and decadal recruitment.

3.1 Fishing pressure estimates availability

For stocks with fishing pressure data (f, HR…) and a corresponding MSY reference point, a time series will display the number of fishing pressure point estimates available for each of the years since 2003. Each stock's detailed time series of f or HR showing annual availability of fishing pressure will be also provided. The total number of stocks as well as the number of stocks by ecoregion is to be provided in a table. In order to mathematically describe the indicators, let us denote the indicator function $\delta(\cdot)$ as:

$$\delta(x) = \begin{cases} 1 & \text{if condition } x \text{ is fulfilled} \\ 0 & \text{otherwise} \end{cases}$$

and $\exists X_j$ meaning that an estimation of X exists for stock *j.*

The indicator is then defined as:

$$N_{\exists F/F_{MSY}}(\mathrm{t}) = \sum_{j=1}^{j=N} \delta\left(\exists f_{jt} \wedge \exists\, F_{MSY\,j}\right)$$

3.2 Design-based indicators

The design-based indicators are derived as a count of the number of stocks that were evaluated to be above or below reference points related to fishing pressure and/or biomass. Each indicator will be provided on a figure and the associated values in a table. The indicators will be provided for each sea basin and for each ecoregion.

3.2.1 Fishing pressure indicator

For stocks with data on fishing pressure (f, HR…) and an associated MSY reference point, the number of stocks for which $f>F_{MSY}$ and the number of stocks for which $f\leq F_{MSY}$ for each year since 2003 is to be displayed. The indicator is defined as:

$$N_{\overline{F_{MSY}}}(t) = \sum_{j=1}^{j=N} \delta\left(f_{jt} > F_{MSY\,j}\right)$$

And

$$N_{F_{MSY}}(t) = \sum_{j=1}^{j=N} \delta\left(f_{jt} \leq F_{MSY\,j}\right)$$

3.2.2 Safe biological limits indicator

For stocks with data on fishing pressure (f, HR…), biomass (B, SSB) estimates and associated precautionary reference points, the number of stocks that are inside safe biological limits ($B\geq B_{PA}$ and $f\leq F_{PA}$) and the number of stocks that are outside safe biological limits ($f>F_{PA}$ or $B<B_{PA}$) for each year since 2003 is to be displayed. The indicator is defined as:

$$N_{\overline{BL}}(t) = \sum_{j=1}^{j=N} \delta\left(f_{jt} > F_{PA\,j} \;\vee\; b_{jt} < B_{PA\,j}\right)$$

And

$$N_{BL}(t) = \sum_{j=1}^{j=N} \delta\left(f_{jt} \leq F_{PA\,j} \;\wedge\; b_{jt} \geq B_{PA\,j}\right)$$

3.2.3 Maximum Sustainable Yield (MSY) indicator

For stocks with data on fishing pressure (f, HR…), biomass (B, SSB) estimates and associated MSY reference points, the number of stocks that have $B \geq B_{MSY}$ and $f \leq F_{MSY}$ and the number of stocks that have $f > F_{MSY}$ or $B < B_{MSY}$ for each year since 2003 is to be displayed. In ICES, as B_{MSY} is not provided, $MSYB_{trigger}$ is assumed to equal B_{MSY} only if $MSYB_{trigger}$ is estimated and not set at B_{PA}. The indicator is defined as:

$$N_{\overline{MSY}}(t) = \sum_{j=1}^{j=N} \delta\left(f_{jt} > F_{MSY_j} \vee b_{jt} < B_{MSY_j}\right)$$

And

$$N_{MSY}(t) = \sum_{j=1}^{j=N} \delta\left(f_{jt} \leq F_{MSY_j} \wedge b_{jt} \geq B_{MSY_j}\right)$$

3.3 Model-based indicators

3.3.1 State-space modelling framework

State-space model (SSM) approach for time series analysis

The state-space model is implemented in the R package 'JARA` (Winker et al., 2020), which is publically available on GitHub (https://github.com/henning-winker/jara). JARA provides the ability to estimate process error and observation error simultaneously. In JARA, each stock trajectory is modelled individually assuming a Markovian process. JARA is run from the statistical environment R and executed in JAGS (Plummer, 2003), using a wrapper function from the R library 'r2jags'. The Bayesian posterior distributions are estimated by means of Markov Chain Monte Carlo (MCMC) simulation. In JAGS, all estimable hyper-parameters are assigned to a prior distribution. JARA uses uninformative prior distributions throughout, so all inferences are drawn from the information in the data.

Model formulation

A central assumption of the state-space approach is that the trend of index I_t in year t follows a Markovian process, such that I_t will be conditioned on I_{t-1}. It is assumed that the underlying population trend follows a conventional exponential growth model $I_t = I_{t-1} \cdot \lambda_{t-1}$, where λ_t is the growth rate in year t. The growth rate λ_t can vary annually to accommodate fluctuations in recruitment, fishing mortality and other time-varying latent (unobservable) effects. The model set up ('mixed.trends' in JARA) is applied so that the trend for each stock j may increase or decline independently from other stocks. The process equation is therefore formulated as $\mu_{t,j} = \mu_{t-1,j} + k_{t-1,j}$ so that $I_{t,j} = \exp(\mu_{t,j})$ where $k_{t,j} = log(\lambda_{t,j})$ is the year-to-year rate of change specific to index j that is assumed to vary around $\bar{k}_j$ to represent the underlying mean rate of change for each stock j, plus a process error variance σ_η^2 that is common to all stocks: $\eta_{t,j} = Normal(0, \sigma_\eta^2)$. Because the process error is lognormally distributed, we adjusted $\eta_{t,j}$ for lognormal bias by subtracting half the process variance at each time step: $k_{t,j} = \bar{k}_j - \eta_{t,j} - (0.5 \times \sigma_\eta^2)$. The corresponding observation equation is $\log(y_{t,j}) = \mu_{t,j} + \epsilon_{t,j}$, so that the expected indicator trend $\mu_{t,j}$ and the error terms $\epsilon_{t,j} \sim Normal\left(0, \sigma_{\epsilon_j}^2\right)$,) are specific to stock j.

Time-Blocks on trend estimation

Time-blocks are implemented in JARA to allow changes in the rate of change not previously experienced as they might be caused by strong management intervention in fisheries or systematic changes in the environmental conditions. Time blocks can also be introduced to conduct short-term forecasts or make predictions over some missing values of some indices in the last data year (caused by the unavailability of stock assessment results). When invoked, the time block is implemented into a process equation as $k_t = \bar{k}_j + \Delta k_j + \eta_{t,j} - (0.5 \times \sigma_\eta^2)$, where $\Delta\bar{k}_j$ denotes the difference in the rate of change form $\bar{k}_j$ (i.e. $\Delta\bar{k}_j = k_{j,t} - \bar{k}_{j,t-n}$), with n defined by the user. Time-block settings for each indicator are provided in table 1.

Observation error

The total observation variance σ_{ε}^2 can be separated into three components: (1) externally derived standard errors $\sigma_{SE_{t,j}}^2$ for each stock j (not used here), (2) a fixed input variance σ_{fix}^2 and (3) an estimable variance σ_{est}^2, where the prior for σ_{est}^2 assumes an uninformative inverse-gamma distribution with both scaling parameters set to 0.001. All three variance components are additive in their squared form, so the total observation variance for stock j and year t is: $\sigma_{\varepsilon_{t,j}}^2 = \sigma_{SE_{t,j}}^2 + \sigma_{fix}^2 + \sigma_{est,j}^2$. Each variance component can be individually switched on or off by the user. Setting a minimum plausible observation error in this way informs the estimate of the process variance as a proportion of the total variance. The ratio is then used to constrain the parameter space of the MCMC process decreasing the likelihood of confounding the two variance components, therefore increasing model stability and convergence of state-space models. The minimum observation error is specified in table 1.

Bayesian framework

The initial index F/F_{MSY}, B or d in the first year $I_{t=1,j}$ is drawn in log-space from an uninformative prior $I_{t=1,j}$. Priors for the process variance (σ_{η}^2) can be either fixed or estimated. If estimated (default), the process variance prior is implemented via a vague inverse-gamma distribution by setting both scaling parameters to 0.001: $\sigma^2 \sim {}^{1}/_{gamma(0.001,0.001)}$, which yields an approximately uniform prior on the log scale. The estimation of annual rate of change in biomass or fishing mortality rate deviates ($k_{t,j}$), is implemented through hierarchical priors, where $k_{t,j}$ is informed by the stock $\bar{k}_j$. Vague normal priors with a mean of 0 and variance of 1000, are assumed for $\bar{k}_j \sim Normal(0,1000)$.

Joint index estimation (indicator trend over multiple stocks)

Calculation of a joint index is simply the averaging of the most probable reconstructed stock trends (i.e. all stocks over the same period). However, in cases where means and variances differ between stocks this can produce biased estimates in the indicator. A non-parametric bootstrap procedure is applied after the MCMC to provide unbiased estimate of the population uncertainty of the indicator from the sample available of stock indicators. This procedure follows in principle the non-parametric procedure of the current protocol, but is highly efficient as it can make use of the MCMC iterations (here 10.500) and therefore does not require refitting JARA many times. Let's note $I_{t,j,s}$ the indicator value for stock *j* at time *t* in the iteration *s* of the MCMC. The bootstrap algorithm comprises the following steps:

1. For each MCMC iteration s,
    (a) Take N stocks with replacement among $I_{t,1\ldots N,s}$ to create a random bootstrap sample for $\tilde{I}_{t,1\ldots N,s}$.
    (b) To obtain a joint index $\bar{I}_{t,s}$, compute the geometric mean across all stocks j as $\bar{I}_{t,s} = \exp(\frac{1}{N}\sum_j \log(\tilde{I}_{t,j,s}))$.
2. The set of $\bar{I}_{t,s}$ provides the posterior distribution for the joint index $\bar{I}_t$
3. Consistent with the current approach, the expected value $\bar{I}_t$ is taken as the median across all $\bar{I}_{t,s}$ posterior iterations and uncertainty is represented by the 25th and 75th (50% confidence intervals) and the 2.5th and 97.5th (95% confidence intervals) percentiles.

3.3.2 Trend in fishing pressure

The F/F_{MSY} indicator is estimated through the procedure detailed in 3.3.1. The trajectory of F/F_{MSY} is fitted for each stock individually and a joint index is derived. The reference point F_{MSY} is defined as the reference point F_{MSY} or as any suitable proxy of F_{MSY} such as, but not limited to, $F_{0.1}$. Stock assessments that estimate harvest rates are not considered.

3.3.3 Trend in biomass

The B/B_{2003} indicator is estimated through the procedure detailed in 3.3.1. The trajectory of SSB (or TSB depending on availability) is fitted for each stock individually and a joint index is derived. The joint index is standardised to the point estimate of 2003 (B_{2003}).

3.3.4 Trend in decadal recruitment

The decadal-recruitment indicator is estimated through the procedure detailed in 3.3.1. The indicator is calculated as follows for each stock *j* and each year t_0:

$$d_{jt_0} = \frac{\sum_{t=t_0}^{t=t_0-9} r_{jt}}{\sum_{t=t_0-10}^{t=t_0-19} r_{jt}}$$

The trajectory of this indicator is fitted for each stock individually and a joint index is derived. The joint index is standardised to the point estimate of 2003.

3.3.5 Trend in biomass for data-limited stocks

The B/B_{2003} indicator for data limited stocks (ICES data-category 3 stocks) is estimated through the procedure detailed in 3.3.1. The trajectory of SSB (or any other biomass/abundance index) is fitted for each stock individually and a joint index is derived. The joint index is standardised to the point estimate of 2003 (B_{2003}).

3.3.6 Model specification

In practice, an R procedure is run using R-package JARA. Two functions are used to build the state-space model (build_jara) and fit it (fit_jara). Available arguments for each function along with their default values and set values if the default is not used are displayed in tables 1 and 2.

Table 1. Arguments, default values and used values for the build_jara function

Argument	Default	If not default
I	NULL	Input data frame
se	NULL	
assessment	"Unnamed"	Sea Basin Name
scenario	"s1"	Indicator type
model.type	"relative"	"mixed.trends"
mixed.scale	"geomean"	
GL	NULL	
start.year	NA	
end.year	NA	
fixed.obsE	NULL	0.05
variance.weighting	"equal"	
sigma.proc.fixed	FALSE	
proc.pen	NULL	
timeblock	FALSE	Final Year – 3 for F/F_{MSY} Final Year – 5 for B Final Year – 5 for d
proj.mod	"theta10"	
pk.prior	c(0.25, 0.1)	
pk.year	NULL	
pk.i	NULL	
proj.r	"all"	
proj.yrs.user	NULL	
proj.stoch	FALSE	
Silent	FALSE	

Table 2. Arguments, default values and used values for the fit_jara function

Argument	Default	If not default
jarainput		build_jara output
credibility	0.95	
ni	9000	
nt	2	
nb	2000	
nc	3	
save.jara	FALSE	
save.all	FALSE	
save.csvs	FALSE	
save.jarafile	FALSE	
peels	NULL	
output.dir	getwd()	
quickmcmc	FALSE	
do.ppc	FALSE	TRUE
jagsdir	NULL	
silent	FALSE	

4 Indicators of advice change

These indicators are computed for the last year of the analysis only, so here t refers to the last year of data.

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

The number of stocks for which estimates of F_{MSY} exist is defined as

$$N_{\exists F_{MSY}}(t) = \sum_{j=1}^{j=N} \delta\left(\exists\ F_{MSY_j}\right)$$

4.2 Number of stocks for which estimates of $MSYB_{trigger}$ exist

The number of stocks for which estimates of $MSYB_{trigger}$ exist is defined as

$$N_{\exists MSYB_{trigger}}(t) = \sum_{j=1}^{j=N} \delta\left(\exists\ MSYB_{trigger_j}\right)$$

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

The number of stocks for which B_{PA} exist is defined as

$$N_{\exists B_{PA}}(t) = \sum_{j=1}^{j=N} \delta\left(\exists\ B_{PA_j}\right)$$

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

The number of stocks for which estimates of B_{MSY} exist is defined as

$$N_{\exists B_{MSY}}(t) = \sum_{j=1}^{j=N} \delta\left(\exists\ B_{MSY_j}\right)$$

4.5 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 the TAC's spatial distribution and the spatial distribution of the stock. The fraction of TACs covered by stock assessments is defined such as:

$$P_{\exists SA/TAC} = \frac{1}{M} \sum_{m=1}^{m=M} \delta(\exists\ O_m)$$

Where O_m represents overlap of the sampling unit m for which the TAC is set using a stock assessment.

5 Additional indicators

Any new indicator that the experts would deem relevant may be included in the annex of the annual ad hoc report produced by the JRC experts. STECF will be tasked to evaluate the relevance and the consistency over time of the proposed indicator.

6 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.

7 Conclusion

This protocol will be used by the JRC experts involved in the production of the indicators included in the annual ad hoc report produced to monitor the performances of the Common Fisheries Policy.

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List of abbreviations and definitions

— f or F represent fishing mortality as reported by scientific advice bodies;

— HR represents harvest rate, e.g. catch / biomass;

— b or B represent biomass, either as total stock biomass (TSB) or spawning stock biomass (SSB);

— 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 (e.g. $F_{0.1}$);

— 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...N stock index, where N is the total number of stocks selected for the analysis;
- t = 1...T year index, where T is the number of years in the reported time series;

— m = 1...M index of sampling units (a descriptor for a given geographical area covered by a TAC for a given species), where M is the total number of stocks in the reference list;

— d is the decadal recruitment which is derived for each year t_0 and stock j as $d_{jt_0} = \frac{\sum_{t=t_0}^{t=t_0-9} r_{jt}}{\sum_{t=t_0-10}^{t=t_0-19} r_{jt}}$;

— ∨ stands for "OR" in Boolean logic;

— ∧ stands for "AND" in Boolean logic;

— $\delta(\cdot)$ an indicator function such as $\delta(x) = \begin{cases} 1 & \text{if condition } x \text{ is fulfilled} \\ 0 & \text{otherwise} \end{cases}$

— $\exists X_j$ means that an estimation of X exists for stock j.

List of tables

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