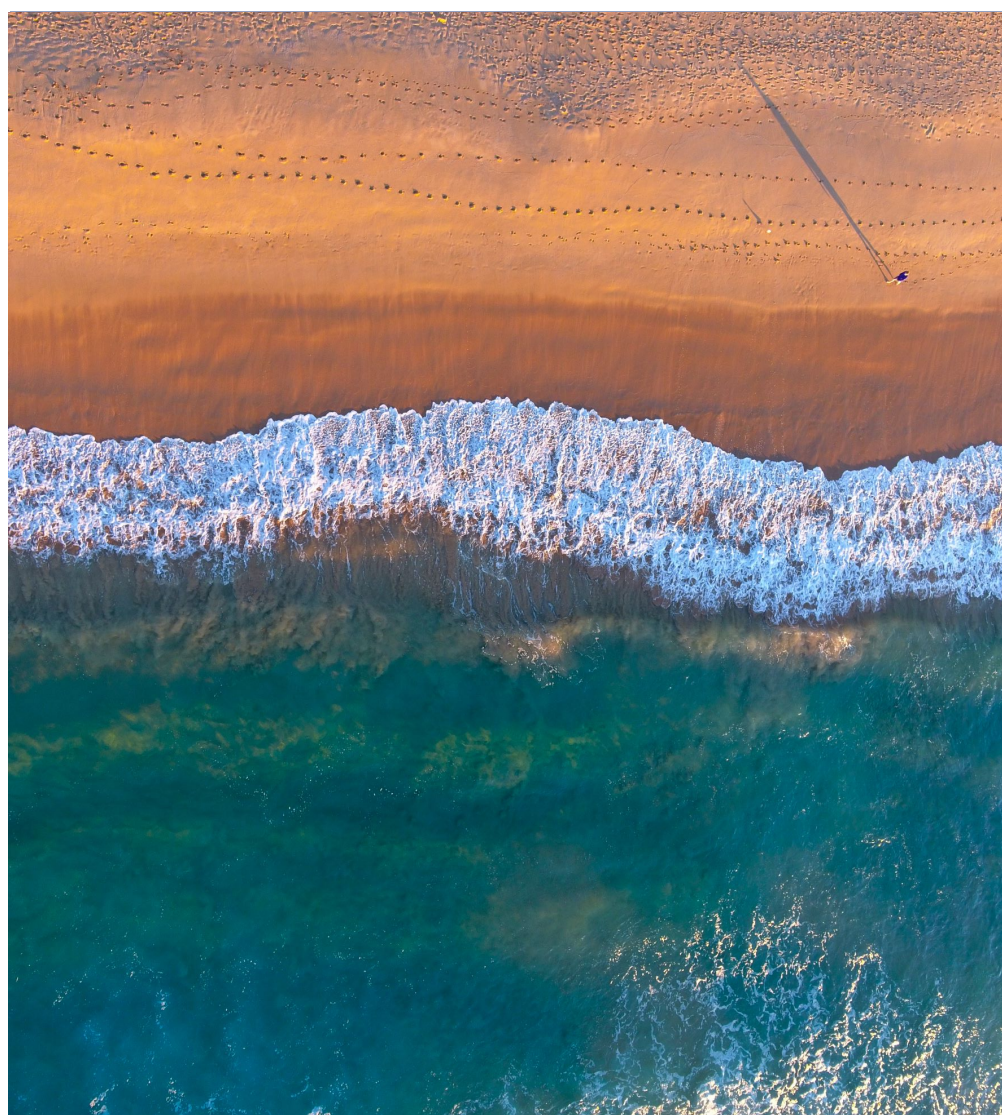


Advice Technical Guidelines

ICES Guidelines - Advice rules for stocks in category 2 and 3

Version 03 | February 2025

**ICES GUIDELINES
AND POLICIES**



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ICES Guidelines and Policies - Advice Technical Guidelines

ICES Guidelines - Advice rules for stocks in category 2 and 3

Version 3 | February 2025

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i Background

Guideline scope

Stocks classified in categories 2 and 3 by the International Council for the Exploration of the Sea (ICES) are considered to be "data-limited". This document is designed to provide clear guidance on the rationale, use, and application of methods to assess stock status, provide catch advice, and short-term forecast for stocks of finfish and shellfish in ICES category 2 and 3 using either the MSY approach or the Precautionary Approach. The primary purpose of these guidelines is to outline the best available scientific methods and advice rules to manage these stocks effectively and sustainably. The intended audience includes scientists working with stock assessment and scientific advice, and other stakeholders involved in the management and conservation of marine resources. These guidelines serve as a comprehensive resource, offering detailed methodologies and advice rules that have been developed and tested to ensure sustainable fisheries management objectives in alignment with biodiversity goals.

Changes since the last version

| Location | Change description |
|---|---|
| Sections 4-9 – for detailed descriptions of changes and additions, see Annex 1. | Changes to Method 1 (SPiCT) so that it aligns with the recommended calculation of catch advice based on a SPiCT; included possibility of lower fractiles for vulnerable stocks; alternative SPiCT HCR can be used for accepted but more uncertain SPiCT assessments. Clarifications for Method 2 (Methods 2.1, 2.2, 2.3) without changes to the methods. |
| Sections 6, 7, and 9 – for detailed descriptions of changes and additions, see Annex 1. | Clarifications for Method 2 (Methods 2.1, 2.2, 2.3) without changes to the methods. Guidelines for other methods were not changed. |
| Sections 3, 4, and Table 1 | Reference to the possibility of zero catch advice for stocks with low biomass was included in Section 3 and 4 and in Table 1. “Zero catch” option added to the diagram in Figure 2. |

Other relevant information

The ICES workshop series on the Development of Quantitative Assessment Methodologies based on Life-history traits, exploitation characteristics, and other relevant parameters for data-limited stocks (WKLIFE) develops and tests methodologies to assess the status of and provide advice for data-limited stocks.

These guidelines are drafted by WKLIFE members and chairs, maintained by the ICES Secretariat staff working with data-limited stocks and ICES Advisory Committee members and leadership. As methods are developed, clarified, and agreed by ACOM, this document will be revised in support of ICES work to provide the best available science to decision-makers.

This ICES guidelines document provides a detailed description of methodology and approach. These methods are subject to external review, and, when approved and adapted by the ICES Advisory Committee (ACOM), are adopted for use in the ICES advice.

This document will be updated as needed.

1 Introduction

ICES provides advice for more than 250 stocks of fish and shellfish. More than 60% of these stocks are “data-limited” in that they do not have full analytical assessments, reference points, or short-term forecasts. Since 2010 ICES has worked to develop and test methods and advice rules for data-limited stocks in order to bring the best available science and information to managers for fisheries and biodiversity goals. To date, ICES data-limited advisory framework and methods were captured in several resources, all based on ICES Guidance for Data-Limited Stocks (ICES, 2012a). Since this initial application, ICES has worked to continuously advance and test the methods and to develop the advisory framework from the precautionary approach towards the MSY approach for data-limited stocks.

This document provides the latest guidance on harvest control rules (HCRs) for use with stocks using a surplus production model in continuous time (SPiCT) assessment and forecast (category 2 MSY advice) and stocks using the empirical methods from WKLIFE X (category 3 MSY advice [Annex 3 in ICES, 2020a]) as illustrated by the orange boxes in Figure 1. The HCRs described here should be applied to relevant stocks, and proxy reference points should be estimated using ICES (2018a) to provide catch advice and stock status for stocks in categories 2 and 3. Further specifications are provided for both short-lived and elasmobranch species using these methods.

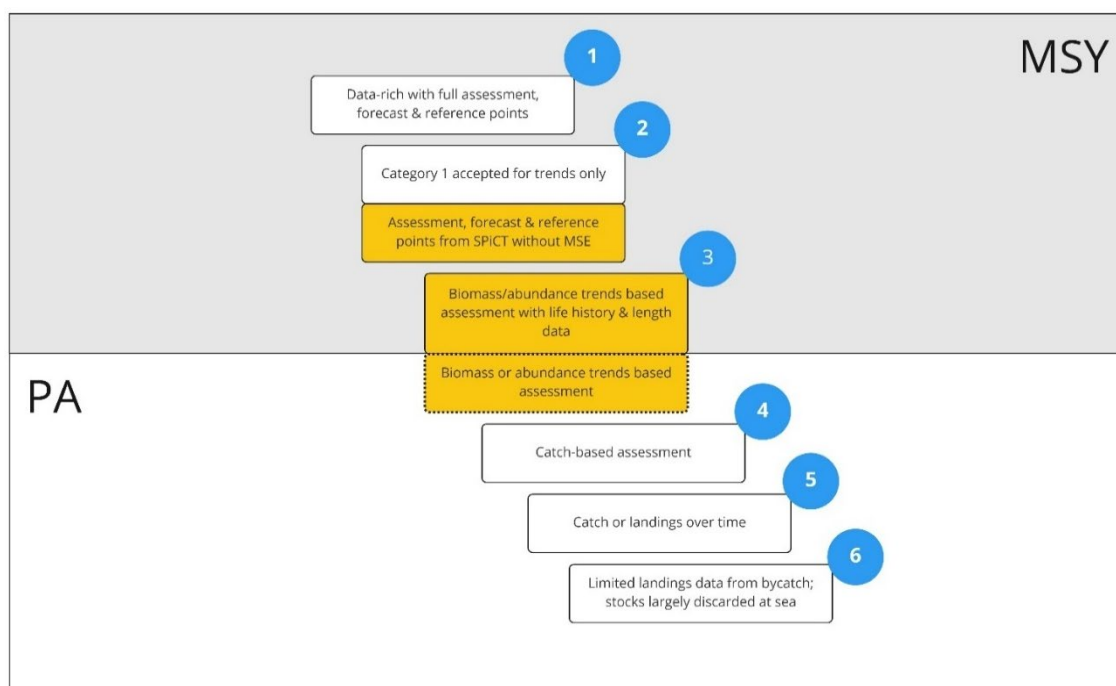


Figure 1. ICES stocks are categorized 1 to 6 by the types of data available and methods used in the provision of advice. These technical guidelines refer only to the orange boxes, categories 2 and 3. The suggested method for category 2 (SPiCT assessment without a management strategy evaluation [MSE] of the HCR) follows ICES MSY approach. The suggested approach for category 3 (empirical methods) includes methods following the MSY approach and, if this is not possible, alternative methods following ICES precautionary approach (PA).

2 Setting the stage

The advice rules presented here have been tested through management strategy evaluation (MSE). Operating models used for the testing were conditioned on life history parameters for a range of stocks, reflecting different life history characteristics and a range of exploitation histories. Such generic testing was necessary given that the rules tested were to be applied to data-limited stocks, where stock-specific parameterization is not feasible (as it is for Category 1).

The methods presented are based on either empirical rules or production models. For the latter case, it remains important to check fits to the data and the plausibility of model estimates and predicted dynamics. The criteria for accepting an assessment (see Method 1 below) are therefore important and will require sufficient peer review before use in advice.

3 Background

ICES stocks are categorized by the types of data available and are used in the provision of advice (Figure 1). Multiple assessment methods are available for each category (ICES, 2012a, 2021a). These technical guidelines are explicitly for stocks in Category 2 (using Method 1) and Category 3 (using Methods 2 and 3).

This document provides a description of advice rules developed by the Workshop on the Development of the ICES Approach to Providing MSY Advice for Category 3 and 4 stocks (WKM-SYCat34; ICES, 2017), the eighth, ninth, and tenth Workshops on the development of quantitative assessment methodologies based on LIFE-history traits, exploitation characteristics, and other relevant parameters for data limited stocks (WKLIFE VIII [ICES, 2018b]; WKLIFE IX [ICES, 2019a]; WKLIFE X [ICES, 2020a]), and the first, second, and third Workshops on data-limited stocks of short-lived species (WKDLSSLS [ICES, 2019b]; WKDLSSLS2 [ICES, 2020b]; ICES WKDLSSLS3 [ICES, 2021a]). These are HCRs used by ICES for data-limited stocks in category 3 (using Methods 2 and 3) and category 2 (using Method 1). The objective of these seven workshops was to investigate the performance of HCRs across life history types through simulation using MSEs. This was done to identify the potential approaches that best meet the goals of management, i.e. maximizing long-term yield while minimizing the probability of stocks falling below biologically sustainable limits. For stocks already depleted with low biomass, zero catch advice may be more appropriate (ICES, 2012a).

4 Applying the advice rules – how to get started

The stock assessment approaches explained in these guidelines include:

- **Method 1:** advice rules for short-term forecasts utilizing a surplus production model (e.g. SPiCT)
- **Method 2:** advice rules for empirical approaches based on life-history traits: the “rfb”, “chr” and “rb” rules
- **Method 3:** harvest control rules (HCRs) for short-lived species: 1-over-2 for short-lived species. These also include an indicative SPiCT, and a “chr” method based on an MSE.

Application of these methods are referenced in the relevant sections throughout this document.

The choice of the appropriate method for a stock is dependent on the availability of data, its ability to fit an acceptable SPiCT model, and the value of the growth coefficient “ k ” in a von Bertalanffy growth function appropriate to the stock (Equation 1).

The hierarchy of method selection and basic details and data requirements of each method are given in the decision tree in Figure 2 and in Table 1. Each approach, along with its constituent components and calculations, is explained in subsequent sections.

In the first instance a SPiCT model should be investigated. If a suitable SPiCT model cannot be developed, then available biomass/abundance time-series data and “ k ” should be explored, with the estimated value of “ k ” indicating choice from Method 2: rfb, chr and rb rules, and the appropriate value of the multiplier (m) to apply.

If available data do not allow for choice from these methods, further direction to lower category assessment is outlined.

$$L(a) = L_{\infty}(1 - \exp(-k(a - t_0))) \quad (1) \text{ von Bertalanffy function}$$

L = length

a = age

k = growth coefficient

t_0 = theoretical age when size is zero,

L_{∞} = asymptotic length

The decision tree flow diagram in Figure 2 shows how to choose the appropriate method for a stock. If expert judgement determines stock biomass index is extremely low relative to historical levels, zero catch advice maybe appropriate because the stock is likely to be below B_{lim} and to remain below B_{lim} even with zero catch in the short-term.

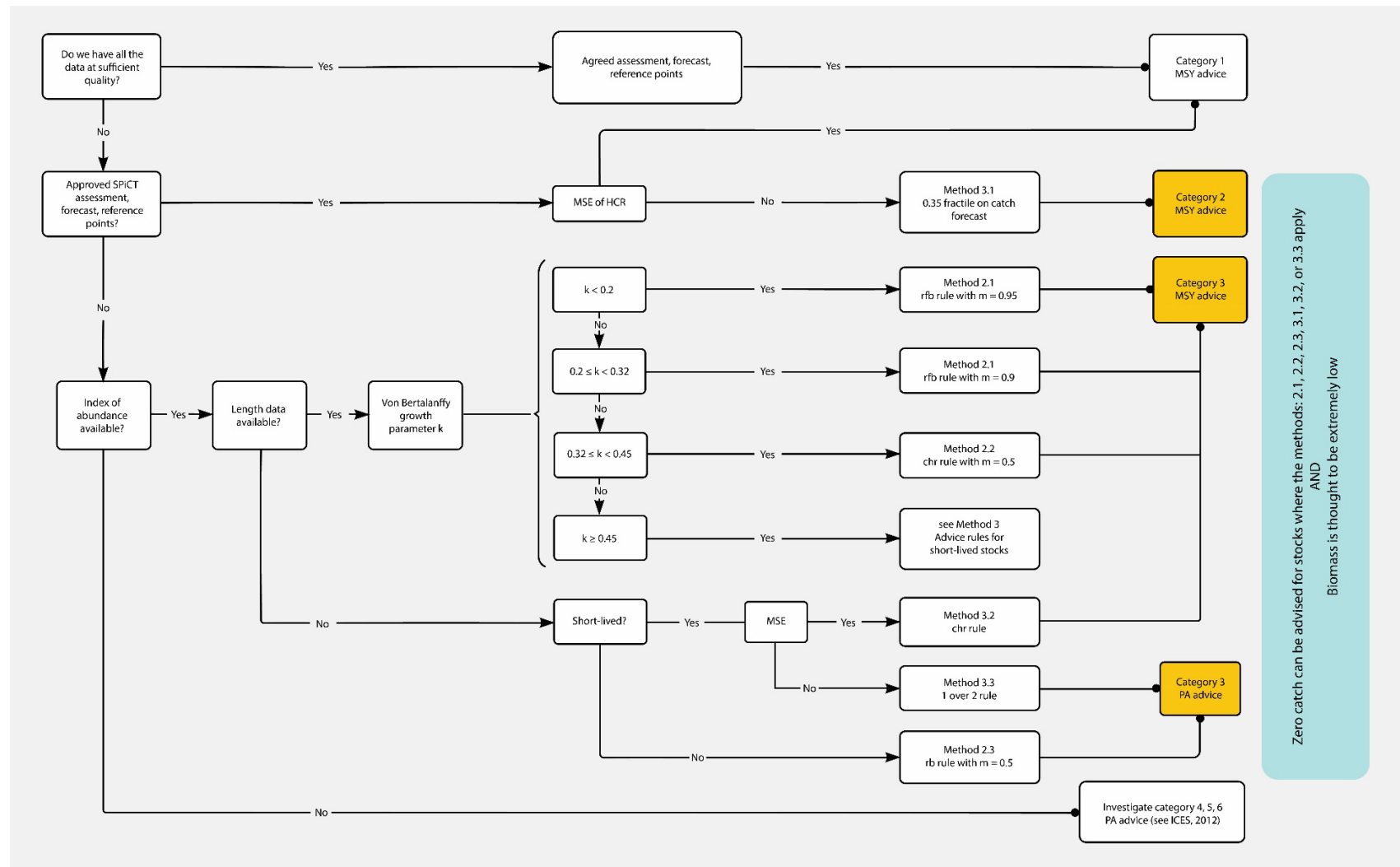


Figure 2. The decision tree for applying ICES advice rules, focusing on the methods covered in this technical guidance and developed by ICES (2021a) and methods for category 3 (category 2 if the technical criteria for accepting a SPiCT assessment are met) stocks with life history information, catch data, and a biomass or abundance index. The boxes on the left side of the diagram refer to the reliable data and information to be used in the provision of advice; “ k ” refers to the von Bertalanffy growth parameter k (unit: yr^{-1}). Note that other models, similar to SPiCT (e.g. Jabba) that have been simulation-tested could be used.

Table 1. Methods, names, brief details, base equations, and data requirements.

| Method | Short name | Details | Base equation | Data requirements |
|----------|--|--|---|---|
| 1 | Advice rules for short-term forecasts utilizing a surplus production model (SPiCT) | | | |
| | SPiCT | Surplus Production model in Continuous Time | | Biomass index time series Catch or landings time series |
| 2 | Advice rules for empirical approaches based on life history traits | | | |
| 2.1 | rfb | A: advised catch or landings r: biomass ratio (survey trend) f: fishing proxy (length data, target) b: biomass safeguard m: multiplier; tuning parameter | $A_{y+1} = A_y \times r \times f \times b \times m$ –30%, +20% stability clause | k, L_{∞} ; von Bertalanffy growth coefficients Biomass time-series Previous year's catch/advice Catch length data |
| 2.2 | chr | Constant harvest rate rule A: advised catch or landings I: biomass index $HR_{MSY\ proxy}$: target harvest rate b: biomass safeguard m: multiplier; tuning parameter | $A_{y+1} = I_{y-1} \times HR_{MSY\ proxy} \times b \times m$ –30%, +20% stability clause | k, L_{∞} ; von Bertalanffy growth coefficients Biomass time-series Catch time-series Catch length data (for first year of application only) |
| 2.3 | rb <i>not for short-lived stocks</i> | A: advised catch or landings r: biomass ratio (survey trend) b: biomass safeguard m: multiplier; tuning parameter | $A_{y+1} = A_y \times r \times b \times m$ –30%, +20% stability clause | Biomass time-series Previous year's catch/advice |
| 3 | Advice rules for short-lived species | | | |
| 3.1 | SPiCT | Surplus Production model in Continuous Time (identical to Method 1, see above) | | |
| 3.2 | chr – MSE | Constant harvest rate rule A: advised catch or landings I: stock index $HR_{MSY\ proxy}$: target harvest rate | $A_{y+1} = I_{current} \times HR_{MSY\ proxy}$ | Current biomass estimate MSY harvest rate proxy from MSE |
| 3.3 | 1-over-2 for short-lived stocks | 1-over-2 rule for short-lived stocks A: advised catch or landings I: biomass index | $A_{y+1} = A_y * (I_y / \text{mean } I_{y-1}:I_{y-2})$ ±80% cap | Biomass time series Previous year's catch/advice |

| Method | Short name | Details | Base equation | Data requirements |
|--------|--|---|---------------|--|
| Other | Zero Catch and landings-based advice rules | | | |
| | Zero catch | For extremely low biomass zero catch is advised for Methods 1–3.3 | | Biomass time series Catch time series |
| | Landings only | Other approaches based on only catch or landings data. ICES assessment categories 4, 5, and 6 (see ICES, 2012a) | | Catch or landings time series |

5 Method 1: advice rules for short-term forecasts utilizing a surplus production model (SPiCT)

The first method to explore is SPiCT; the stochastic surplus production model in continuous time (SPiCT; Pedersen and Berg, 2017). SPiCT is a state-space re-parameterized version of the Pella-Tomlinson surplus production model (Pella and Tomlinson, 1969); i.e. it quantifies observation and process errors and estimates stock status and reference levels with associated confidence intervals.

Note that other similar models (e.g. Jabba) that have been simulation-tested could be used.

- SPiCT provides fishing mortality and biomass reference points and a short-term forecast for stocks with a biomass index and a catch time-series.
- The technical criteria to accept a SPiCT assessment are given below; more detailed information and example code is included in the SPiCT technical guidelines (Mildenberger *et al.*, 2021), which is a living document maintained by the developers of SPiCT.
- A fractile rule (see 5.3) is used for the catch advice. Without a stock-specific MSE of the HCR, the default rule agreed by ACOM, on the basis of recommendations from WKLIFE, is the 35th percentile, and this should result in a category 2 stock assessment and advice. A stock-specific MSE of the HCR for a stock with a SPiCT assessment can be conducted where possible to establish that the HCR (comprised of limit and target biomass reference points and their fractiles) is robust to uncertainty and meets predefined management objectives.

5.1 Technical criteria for accepting a SPiCT assessment

When determining harvest limits using output from SPiCT, appropriate application first depends on model performance. An accepted assessment using SPiCT has to fulfil **all** of the following criteria:

1. The optimization has converged.
2. All variance parameters of the model parameters are finite.
3. There should be no serious violation of model assumptions based on one-step-ahead residuals (bias, autocorrelation, normality). This means that p-values of the relevant statistical tests, implemented in SPiCT, should be insignificant ($p > 0.05$). Slight violations of these assumptions do not necessarily invalidate model results. For example, autocorrelation and normality issues should be examined. Autocorrelation in the residuals can occur when indices with conflicting signals are used. Normality issues can occur when there are outliers in the input time series, especially observations close to zero.
4. There should be consistent patterns in the retrospective analysis. This means that there is no tendency of consistent under- or overestimation of the relative fishing mortality (F/F_{MSY}) and relative biomass (B/B_{MSY}) in successive assessments. The retrospective trajectories of those two quantities should be mostly inside the confidence intervals of the run including all years of data; most importantly at the end of the time series. Mohn's rho for both quantities is reported by SPiCT. Mohn's rho values should be inside ICES acceptable ranges, and the number of peels should follow standard ICES practice (ICES, 2020c).

5. There should be a realistic production curve. The shape of the production curve should not be too skewed (B_{MSY}/K , where K is the carrying capacity estimate, should be between 0.1 and 0.9). Low values of B_{MSY}/K allow for an infinite population growth rate.
6. The main variance parameters (i.e. of the biomass and fishing mortality processes, and the catch and index observations) should not be unrealistically high. Confidence intervals for B/B_{MSY} and F/F_{MSY} should not span more than one order of magnitude. Note that this does not hold for short-lived, fast-growing species, where the confidence intervals are expected to be larger. High assessment uncertainty can indicate a lack of contrast in the input data or violation of the ecological model assumptions.
7. Initial values should not influence the parameter estimates. The optimization should converge to the same estimates when starting from different initial parameter values.

5.2 Caveats of SPiCT

Different options can be explored to stabilize SPiCT for data with low contrast or high observation errors. SPiCT allows the use of prior probability distributions, for example on the shape of the production curve or the initial depletion level, which can help stabilize the optimization procedure. However, using priors with lower standard deviations affects the posterior results (confidence intervals and parameter estimates). Several options to stabilize SPiCT assessments have been explored and tested within WKLIFE VIII and IX and are described in detail in the SPiCT technical guidelines (ICES, 2018b, 2019a; Mildenberger *et al.*, 2021).

5.3 Fractile rules and biomass reference points for catch advice based on SPiCT

ICES developed an MSY HCR (“median rule”) for assessments using SPiCT (Section 3.1 in ICES, 2017). The median rule, as with the category 1 HCR, is based on two biomass reference points, a trigger reference point ($MSY B_{trigger}$), and a limit reference point (B_{lim}). Currently, B_{lim} is defined as $0.3 B_{MSY}$ and $MSY B_{trigger}$ is defined as $0.5 B_{MSY}$ for surplus production models such as SPiCT (ICES, 2021a).

Based on the median rule, WKLIFE VII-X developed and evaluated the more precautionary “fractile rules” that account for uncertainty and demonstrated that the fractile rules are more effective and precautionary than the median rule and the “2-over-3” rule (ICES DLS Method 3.2; ICES, 2012a; 2018b; 2018c; 2019a; 2021a). Furthermore, the standard category 1 HCR that is based on two biomass reference points, a trigger reference point ($MSY B_{trigger}$), and a limit reference point (B_{lim}) is used. The two biomass reference points should depend on each other, e.g. be fractions or multiples of a common reference point like B_{MSY} (Mildenberger *et al.*, 2022)."

The target fishing mortality, F_{pred}^{τ} , during the management period depends on the expected relative biomass at the start of the management period ($\frac{B_y}{MSY B_{trigger}}$) and the fishing mortality at MSY (F_{MSY}). Thus, the target fishing mortality corresponds to the median rule proposed by WKM-SYCat34 (ICES, 2017):

$$F_{pred}^{\tau} = F_{MSY} \min \left(1, \frac{B_y}{MSY B_{trigger}} \right) \quad (2)$$

Many SPiCT assessments are based on data with limited contrast (such as one-way-trip biomass indices or catch time series), do not account for substantial discards or recreational catches, or

use a biomass index based on commercial CPUE rather than a fisheries-independent survey. In these cases, the 35th percentile of the distribution of all three quantities (f^C , f^B , f^F) could be considered. A more precautionary target fishing mortality accounts for the uncertainty in estimated relative fishing mortality and relative biomass:

$$F_{pred}^{\tau} = F_y \frac{\min\left(1, \frac{\Phi^{-1}\left(\frac{B_y}{MSY B_{trigger}}\right) (f^B)}{\Phi^{-1}\left(\frac{1-f^F}{F_{MSY}}\right)}\right)}{\Phi^{-1}\left(\frac{1-f^F}{F_{MSY}}\right)} \quad (3)$$

where f^B and f^F are the fractiles lower than 0.5 (Mildenberger *et al.*, 2022).

Therefore, to account for the extra uncertainty, for stocks that have an accepted SPiCT assessment, ICES uses the fractile rule with the 35th percentile of the predicted catch distribution ($f_{0.35}^C$) for the catch advice. In theory, with increasing time-series lengths and decreasing observation error, the estimated catch with the $f_{0.35}^C$ rule approximates the median rule suggested by ICES (2017) while being more precautionary.

The $f_{0.35}^C$ rule estimates the catch advice (A) based on the 35th percentile of the predicted catch distribution given the target fishing mortality F_{pred}^{τ} during the management period.

$$A = \Phi^{-1}_{(C_{pred}|F_{pred}^{\tau})}(0.35) \quad (4)$$

where Φ^{-1} is the inverse distribution function, thus $\Phi^{-1}_{(C_{pred}|F_{pred}^{\tau})}(0.35)$, is the catch that corresponds to the 35th percentile of the estimated catch distribution.

For stocks of species that are more vulnerable to fishing pressure, for example characterized by slow growth and late maturation, a more precautionary rule with a lower percentile of the catch distribution, such as the 15th percentile, is suggested to account for the increased risk of fishing (WKLIFEXIII report; ICES, 2024).

If the biomass at the start of the management period (B_y) is below B_{lim} , the recommended catch advice should be zero.

5.4 Application of the fractile rules based on SPiCT

Annual and multiannual advice cycles using the fractile rules have been tested within MSEs. The best performance can be expected with annual advice cycles allowing for adaptive management actions, but the rules are also applicable in biennial advice cycles.

If a SPiCT assessment is not accepted, Method 2 advice rules based on life history traits and length frequency data should be explored.

6 Method 2: advice rules for empirical approaches based on life-history traits

It is recommended that SPiCT be attempted first. If SPiCT is found not to be appropriate for the stock, an empirical approach (i.e. a model-free, length-based method) should be explored. This section (Method 2) describes three empirical control rules (the rfb rule, the chr rule, and the rb rule). These methods have been developed and tested with MSEs and have been designed to explicitly follow ICES precautionary approach, i.e. the long-term risk of stocks falling below the limit reference point B_{lim} below which recruitment is thought to be impaired does not exceed 5%.

The process may require estimation of k (the von Bertalanffy growth parameter) and length data.

The simulation work on the rfb and chr rules presented in ICES (2018b, 2018c, 2019a, 2021a) is peer-reviewed and published in four articles in the ICES Journal of Marine Science (Fischer *et al.*, 2020, 2021a, 2021b, 2022). Fischer *et al.* (2020) also provide extensive robustness tests and a detailed description of the operating models used.

The MSE simulations were conducted using FLR (Kell *et al.*, 2007) and FLR's MSE package. The source code for the simulation in this section is available on GitHub¹

6.1 Generic application

The advice rules presented here were tested for the types of data that are typically available. The testing was done generically to ensure wider application of the rules. Generic simulations included a diversity of stocks (fast/slow-growing, short/long-lived, roundfish, flatfish, and elasmobranchs; 29 stocks total), two alternative fishing histories, and explicit MSY and precautionary considerations. Any change from the generic parameters of the control rules should be justified with case-specific simulations.

6.2 Stock-specific application

Case-specific simulation testing and optimization of the parameters of the control rules may be conducted to better tune the assessment to a particular stock while still following the ICES precautionary approach (e.g. if time-lags are reduced so that more recent information is used, or individual components of the rule are weighted differentially based upon improved knowledge). Fischer *et al.* (2023) illustrate how the methods could be tuned to specific stocks and WKLife XI (ICES, 2023, section 2.2.6, p. 26) includes some recommendations for stock-specific simulations. In the absence of such additional simulation testing, it is recommended that the rules presented below, with associated generic multipliers, be applied.

The applicability of the methods presented here depends on the individual growth rate of the harvested species, expressed through the von Bertalanffy growth parameter k (unit: year⁻¹), see the flowchart in Figure 2. Applying these methods beyond their recommended k -range might be possible if case-specific simulations support this.

¹ <https://git.io/JTF9q> (There are several branches of this repository for different analyses.)

6.3 Multiplier (m)

All empirical control rules of Method 2 include a multiplier (m). The multiplier values were selected so that the risk of falling below B_{lim} is not greater than 5% in the long term. Incorporating a multiplier less than one will decrease risk (i.e. a reduced probability of the stock falling below B_{lim}) by buffering against the uncertainty associated with each component of the HCR, and thus leading to the appropriate management action, given these uncertainties. The risk of the stock falling below B_{lim} is related to the life history dynamics of the stock. It is recommended that the application of the HCR includes a life history-based multiplier to reduce risk. For the rfb rule (Method 2.1) and the chr rule (Method 2.2), the multiplier adjusts the target of the methods (the reference catch length for the rfb rule, the target harvest rate for the chr rule). Section 3.6 in WKLife X (ICES, 2020a) provides the justification for the multipliers associated with each method below.

6.4 Stability clause

An asymmetric stability clause (uncertainty cap) of +20% and -30% is recommended where the advised catch would be limited to increase by a maximum of 20% or decrease by a maximum of 30% relative to the most recently **advised catch** in all applications of the empirical rules. The application of the cap is conditional on the biomass safeguard (b) of the empirical rules and should be ceased as soon as $b < 1$, i.e. when the most recent index value falls below $I_{trigger}$ (see details below for the empirical rules). This is meant to ensure greater flexibility in catches (both for decreases and increases) when the stock is estimated to be below its trigger value. The values for the stability clause are based on the considerations of Fischer *et al.* (2020, 2021b).

6.5 Advice interval

The recommendation is to apply the rfb rule (Method 2.1) and the rb rule (Method 2.3) with biennial advice (i.e. the catch advice is set for two years), and the chr rule (Method 2.2) with annual advice (i.e. the catch advice is set every year). These recommendations are based on the outcomes of simulations which have shown that, particularly for trend-based rules (rfb and rb), setting the advice more frequently does not necessarily lead to better management performance and can increase the risks for stocks falling below B_{lim} .

ICES (2023) re-evaluated the advice intervals and concluded that applying the rfb or rb rule annually instead of biennially and the chr rule biennially instead of annually is unlikely to increase the long-term risk of stocks falling below B_{lim} ; however, this will likely reduce the catch advice in the long term. Consequently, the default advice interval should not be changed unless explicitly asked for by advice requesters.

6.6 Biomass index

All empirical control rules of Method 2 require a biomass index. This biomass index is meant to represent biomass of the stock and does not require an age structure. The index should be representative of the stock size and spatial distribution. It is possible to combine several indices for better coverage of the stock unit (e.g. VAST [Thorson *et al.*, 2019]) was used for ple.27.7h-k in 2021 [ICES, 2021b]). For the rfb and rb rules (Methods 2.1 and 2.3), at least five years of data are required.

6.7 Biomass safeguard

All generic empirical control rules of Method 2 include a biomass safeguard. This biomass safeguard reduces the catch advice when the stock falls below a threshold, and this is measured by comparing the level of a biomass index to a trigger value ($I_{trigger}$). This trigger value should be set to the level below at which the stock's productivity is impaired (e.g. $0.5B_{MSY}$). Care should be taken when determining this value based on the stock productivity as well as its susceptibility to effects from fishery-specific activities.

6.8 Reference catch (for rfb and rb rules)

The rfb rule (Method 2.1) and the rb rule (Method 2.3) work by adjusting a reference catch, usually the previous catch advice A_y . If no previous catch advice exists, e.g. when catch advice is given for the first time, the reference catch can be based on the most recent catch C_{y-1} or the average catch of the last three years. When the methods are applied for the first time, and the previous advice values are substantially different from catches (for example, consistently more than 20% higher or lower, or the advice is zero, but the catches are not zero), A_y could be replaced with the most recent realised catches or an average thereof. This is because these methods are meant to adjust the realised catches influencing the stock. This should only be considered in the first year of the application, and in subsequent years, the reference catch should revert to the previous advice value.

6.9 Length data

The rfb rule (Methods 2.1) uses length data from the catch to estimate a fishing proxy. Furthermore, the chr rule (Method 2.2) also uses length data the first time it is applied to set a target harvest rate. The length data should cover total catches (landings and discards) and be representative of the fishery and ideally cover all fleets or gears. If this is not possible, samples from a subset of the fishery can be used if representative of the whole fishery to ensure that mean length in the catch and length reference points are comparable. If catch length data are unavailable, survey data may be used but the length distribution used should not include lengths less than the length of first capture in the fishery and should be representative of that found in fishing gears in the fishery. The catch length data are used to calculate the mean length in the catch as a proxy of the fishing pressure. For this purpose, only lengths above the length at first capture L_c are considered. L_c should be determined following ICES (2021b, Section 3.4.1) and this process is described in Table 2.

In general, it is recommended to estimate length reference values (such as L_c) by pooling length data from several years and using these constant values for subsequent calculations (for example, the annual mean catch length should then be calculated with the constant L_c). This approach can reduce the influence of noise in the data. There may be cases when length reference values need to be changed over time or be calculated annually, for example, because of changes in the fishery selectivity.

6.10 Fishing proxy (for rfb rule)

The rfb rule includes a fishing proxy that is intended to move fishing pressure on the stock towards F_{MSY} . The fishing proxy is taken as the mean length in the observed catch (L_{y-1}) and is assumed to be inversely correlated to fishing mortality. The fishing proxy is calculated as the mean catch length relative to an MSY proxy length ($L_{F=M}$). The reference value $L_{F=M}$ is rearranged

from Beverton and Holt's equation (Beverton and Holt, 1957) for mean length in the catch as a function of the von Bertalanffy growth parameters (L_∞ , k), length at first capture (L_c), natural (M) and fishing mortality (F). It simplifies to $0.75L_c + 0.25L_\infty$ under the assumption of $M/k=1.5$. This reference value therefore gives the length in the catch expected from fishing at $F=M$ in the long term. To adequately reflect exploitation status, the indicator L_{y-1} should be calculated from catch data or data that are representative of the fisheries on the stock. If L_{y-1} is less than $L_{F=M}$ then fishing mortality is likely to be larger than M and hence F_{MSY} .

6.11 Reference values and updates

The rfb, rb, and chr rules include reference values such as a trigger value for the biomass index (I_{trigger}), the length at first capture (L_c), a length reference value ($L_{F=M}$), or the target harvest rate $HR_{MSY \text{ proxy}}$. These values should be set when the methods are applied for the first time and should not be updated for every application. The values could be periodically re-evaluated every few years, similar to benchmarks for data-rich stocks. If substantial changes in the fishery are known to have happened, this may affect L_c and $L_{F=M}$.

If the biomass index is modelled, the historical time series can also change, and this may require updating reference values such as I_{trigger} . It can be useful to define biomass index reference values relative to the biomass index value in a specific year (e.g. $I_{\text{trigger}} = I_{2007} \times 1.4$), which means that the actual value of the reference point is scaled accordingly.

6.12 Software

An R package (cat3advice) facilitating the application of the rfb, rb, and chr rules is available on GitHub (<https://github.com/shfischer/cat3advice>).

7 Method 2.1: rfb rule

The rfb HCR (Eq. 5) provides MSY advice for category 3 stocks based on the stock trend from a biomass index (similar to the previously used “2-over-3 rule”, ICES 2012a), the mean length in the catch relative to an MSY proxy length, and a biomass safeguard to ensure compliance with ICES precautionary approach (ICES, 2017; Fischer *et al.*, 2020, 2021a, 2021b). The three name-giving elements of the rfb rule are:

r: biomass ratio (survey trend)

f: fishing proxy (length data, target)

b: biomass safeguard

This HCR improves on the “2-over-3” rule (ICES, 2012a), with the addition of multipliers based on a stock’s life history characteristics, its status in terms of relative biomass, and its status relative to a target reference length (ICES, 2018c, 2019a).

The rfb catch rule is defined as:

$$A_{y+1} = A_y \times r \times f \times b \times m \quad (5)$$

where the advised catch (A) for next year $y+1$ (set on a biennial basis) is based on the most recent year’s advised catch A_y adjusted by the components in Table 3.

Table 2. Data requirements of the rfb rule.

| Component | Details |
|-------------------------|--|
| Previous catch advice | <ul style="list-style-type: none"> If no previous catch advice (A_y) exists, use the most recent catch (C_{y-1}), or the average of the last three years of catch If C_y is very different (e.g. consistently $\pm 20\%$ different, greater than zero for zero catch advice) from A_y, consider replacing A_y in the first application of the rule as the rfb rule is meant to adjust realised catches influencing the stock. See also the general text above (section “Reference catch (for rfb and rb rules)”)) |
| Biomass index | <ul style="list-style-type: none"> At least five years of data needed Without age structure Should be representative of the stock It is possible to combine indices for better coverage of the stock unit (e.g. VAST [Thorson <i>et al.</i>, 2019) was used for ple.27.7h-k in 2021 [ICES, 2021b]). |
| Length data | <ul style="list-style-type: none"> At least one year of data needed Should be representative of the fishery (ideally covering all fleets or gears; if not possible, ensure that mean length in the catch and length reference points are comparable, survey data can be used if necessary) Use total catch (if available) Calculate mean length in the catch (consider lengths greater than length at first capture L_c) If the distribution is noisy, consider increasing the bin width or applying a smoother Length at first capture L_c can be determined with the following approach: <ol style="list-style-type: none"> Find the mode of length distribution (length class with highest catch numbers N_{max}) Find first length class where catch is at or above $N_{max}/2$. This is the length at first capture L_c For estimating the mean catch length, consider only length classes above L_c If the length distribution is noisy, consider increasing the bin width or applying a smoother |
| Life history parameters | <ul style="list-style-type: none"> von Bertalanffy growth parameters: k, L_∞ |

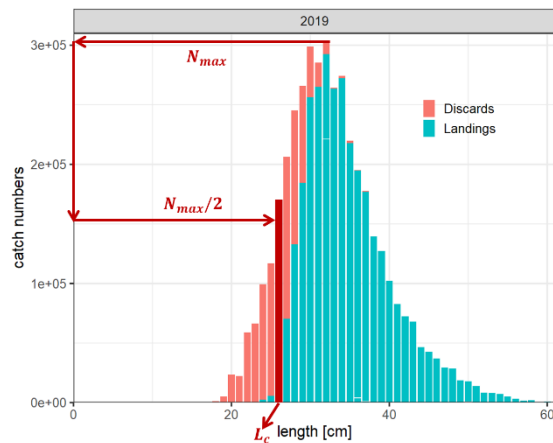


Table 3. Components of the rfb rule.

| Component | Definition | Description and use |
|------------------|---|--|
| A_{y+1} | $A_y \times r \times f \times b \times m$ | The advised catch for next year $y+1$ (set on a biennial basis). |
| A_y | | The most recent year's advised catch (or catch, see section "Reference catch (for rfb and rb rules)" above on p. 13). |
| r | $\frac{\sum_{i=y-2}^{y-1} (I_i/2)}{\sum_{i=y-5}^{y-3} (I_i/3)}$ | The rate of change in the biomass index (I), based on the average of the two most recent years of data ($y-2$ to $y-1$) relative to the average of the three years prior to the most recent two ($y-3$ to $y-5$), and termed the "2-over-3" rule; y = assessment (intermediate) year. |
| f | $\frac{\bar{L}_{y-1}}{L_{F=M}}$ | The fishing proxy is the mean length in the observed catch (\bar{L}_{y-1}) relative to an MSY proxy length ($L_{F=M}$) and is intended to be at a level that moves the stock towards MSY. Only lengths above the length of first capture (L_c) are considered for \bar{L}_{y-1} . The target reference length is $L_{F=M} = 0.75L_c + 0.25L_{\infty}$, where L_c is defined as length at 50% of modal abundance (ICES, 2012b, 2018a). The reference length follows Beverton and Holt (1957), derived by Jardim et al. (2015), and assumes $M/k = 1.5$. |
| b | $\min\left\{1, \frac{I_{y-1}}{I_{\text{trigger}}}\right\}$ | Biomass safeguard. Adjustment to reduce catch when the most recent index data I_{y-1} is less than $I_{\text{trigger}} = 1.4I_{\text{loss}}$ such that b is set equal to $I_{y-1}/I_{\text{trigger}}$. When the most recent index data I_{y-1} is greater than I_{trigger} , b is set equal to 1. I_{loss} is generally defined as the lowest observed index value for that stock. I_{trigger} may need to be adapted if the stock has been exploited only heavily or lightly in the past. |
| m | $[0,1]$ | A tuning parameter to ensure that the rfb rule is precautionary (that risk does not exceed 5%). It does not decrease advice continuously but can be considered as adjusting the target in component f . m is linked to von Bertalanffy k and based on generic MSE simulations. May range from 0 to 1.0. |
| Stability clause | $\min\{\max(0.7A_y, A_{y+1}), 1.2A_y\}$ | Asymmetric conditional stability clause. Limits the amount the advised catch (A_{y+1}) can change upwards or downwards relative to the previous catch advice (A_y). The recommended values are +20% and -30%; i.e. the catch would be limited to a maximum 20% increase or a maximum 30% decrease relative to the previous year's advised catch. The stability clause does not apply when $b < 1$. |

Each component of the HCR is multiplied together in order to determine next year's catch advice by adjusting this year's catch advice upwards or downwards. This is based on the trend in the index (i.e. whether the stock is going up or down; r), the observed mean length in the catch relative to the target mean length (f), and a factor to adjust catch downwards if the current stock falls below a threshold index value (b). The multiplier (m) is then applied as a precautionary measure to ensure that the probability of the stock falling below B_{lim} is less than or equal to 5%.

The performance of the catch rule is driven largely by three factors:

- The life history of the species
- The trend in the index being a good measure of the current status of the stock based on its life history
- The $I_{trigger}$ value being defined at or near the true threshold level (e.g. $0.5B_{MSY}$).

7.1 Choosing the multiplier m

For the harvest estimate for longer-lived stocks with low natural mortality and slow individual growth (von Bertalanffy $k < 0.2 \text{ yr}^{-1}$; e.g. redfish or ling), a multiplier of $m = 0.95$ should be applied to the control rule ($A_{y+1} = A_y \times r \times f \times b \times 0.95$), i.e. by setting the estimated catch for the following year to 95% of the estimated yield, based on the control rule. Medium-lived stocks with $0.2 \leq k < 0.32 \text{ yr}^{-1}$ (e.g. plaice, red mullet) should apply a multiplier of $m = 0.90$ to next year's estimated catch. If there is no reliable information about k – but k is considered to be less than 0.32 yr^{-1} – then the more precautionary multiplier of $m = 0.90$ should be used.

7.2 von Bertalanffy growth parameter k

The von Bertalanffy growth parameter k is an individual growth rate. For these advice rules, only a rough estimate of k is needed: $k < 0.2 \text{ yr}^{-1}$ or $0.2 \leq k < 0.32 \text{ yr}^{-1}$. Ideally, stock-specific values (e.g. using age-length data) should be used, but an alternative k might be borrowed from another adjacent stock of the same species or from the literature using expert judgement. Survey data or catch data can be used as the data source, and data sources can be combined to ensure that sufficient young and old individuals are included. Note that the rfb rule is not recommended for stocks with $k \geq 0.32 \text{ yr}^{-1}$ (see Figure 2).

7.3 Elasmobranch stocks

The rfb rule can be used for elasmobranch stocks, which are generally slow-growing stocks. ICES (2020a) evaluated the performance of this rule and showed that the rfb rule resulted in more stable risks, irrespective of the fishing history of the stock. See Section 3.6 in ICES (2021a) for further details.

In the past, other ratios were used for category 3 elasmobranch stocks (e.g. 2-over-5). This practice is no longer supported as ICES (2020a) showed that ratios like 3-over-5 versus 2-over-3 result in higher risk, slower recovery, and higher uncertainty that can be detrimental to the stock. The 2-over-5 rule compared to the rfb rule leads to much higher risks for elasmobranch stocks when over-exploitation has occurred.

7.4 Deep-water stocks

If not known for the specific stock it is likely that $k < 0.2 \text{ yr}^{-1}$ (slow growing).

7.5 Advice interval

Method tested with advice every two years (biennial).

7.6 Considerations

- Use the most recent data available (e.g. I_y instead of I_{y-1}).
- Do not change the interval (or any other parameter of the rfb rule) without simulations that support it.
- The rfb rule can not technically produce zero catch advice. If the biomass index is very low, and determined by expert judgement to be below any reasonable B_{lim} , then zero catch advice should be given
- The average of recent catches can be used as the basis of advice in the first application of the rule OR when zero advice has been given previously and the biomass index has shown a clear increasing trend, particularly if it has increased above $I_{trigger}$.

8 Method 2.2: constant harvest rate (chr) rule

The constant harvest rate (chr) rule, also called the F_{proxy} rule (ICES, 2017), or the “Icelandic” rule, (ICES (2017)). It applies a constant harvest rate ($HR_{proxy,MSY proxy}$) that is considered a proxy for an MSY harvest rate and applies this to the index.

The chr rule was developed to address cases where $k \geq 0.32 \text{ yr}^{-1}$, and the rfb rule should not be applied. See Section 3.6.1 in ICES (2020a) for a justification of the multipliers to ensure that the long-term risk of falling below B_{lim} does not exceed 5%, in compliance with ICES precautionary approach.

ICES (2017) proposed that historical data be used to define $HR_{MSY proxy}$, so the approach used here is to extract the ratio C_y/I_y from those historical years for which the quantity $f > 1$, where f is the ratio of mean length above L_c relative to $L_{F=M}$, and to calculate the target harvest rate as the mean of this C_y/I_y ratio.

Simulation testing of this rule found this was suitable for stocks where $0.32 \leq k < 0.45 \text{ yr}^{-1}$ (where k is the von Bertalanffy growth parameter, see Section 3.4 in ICES [2020a])

$$A_{y+1} = I_{y-1} \times HR_{MSY proxy} \times b \times m \quad (6)$$

where the advised catch (A) is for next year $y+1$ (set on an annual basis). Table 4 lists the data requirement for the chr rule and the components of the chr rule are presented in Table 5.

Table 4. Data requirements of the chr rule.

| Component | Details |
|-----------------------|--|
| Previous catch advice | <ul style="list-style-type: none"> Only required for the application of the stability clause. |
| Biomass index | <ul style="list-style-type: none"> See Section 6.6 for details. The application of the chr rule requires only one biomass index value but more years are needed to calculate the target harvest rate. |
| Length data | <ul style="list-style-type: none"> Length data are only required in the first year the chr rule is implemented to calculate the target harvest rate. See Section 6.9 for details on the use of length data and Section 7 for the calculation of the fishing proxy and length reference values. |

Table 5. Components of the chr rule.

| Component | Definition | Description and use |
|-------------------|--|---|
| A_{y+1} | $I_{y-1} \times HR_{MSY\ proxy} \times b \times m$ | The advised catch for next year $y+1$ (set on an annual basis) |
| I_{y-1} | | The most recent index value, usually from year $y-1$. A more recent index value (e.g. I_y) can be used if available |
| $HR_{MSY\ proxy}$ | $\frac{1}{u} \sum_{y \in U} C_y / I_y$ | Target harvest rate. The mean of the ratio C_y / I_y for the set of historical years U for which the quantity $f > 1$, and u is the number of years in the set U . C_y are observed catches and I_y index values for corresponding historical years. The quantity f is the ratio of the mean length in the observed catch that is above the length of first capture relative to the target reference length (mean length/target reference length). The target reference length is $L_{F=M} = 0.75L_c + 0.25L_\infty$, where L_c is defined as length at 50% of modal abundance (ICES, 2012b, 2018a). See the rfb rule (Method 2.1) above for details. |
| b | $\min \left\{ 1, \frac{I_{y-1}}{I_{trigger}} \right\}$ | Biomass safeguard. Adjustment to reduce catch when the most recent index data I_{y-1} is less than $I_{trigger} = 1.4I_{loss}$ such that b is set equal to $I_{y-1} / I_{trigger}$. When the most recent index data I_{y-1} is greater than $I_{trigger}$, b is set equal to 1. I_{loss} is generally defined as the lowest observed index value for that stock. $I_{trigger}$ may need to be adapted if the stock has been exploited only heavily or lightly in the past. |
| m | $[0,1]$ | Multiplier applied to the HCR to maintain the probability of the biomass declining below B_{lim} to no more than 5%. It does not decrease advice continuously but can be considered as adjusting the target ($HR_{MSY\ proxy}$). The m component may range from 0 to 1.0. |
| Stability clause | $\min \{ \max(0.7A_y, A_{y+1}), 1.2A_y \}$ | Asymmetric conditional stability clause. Limits the amount the advised catch (A_{y+1}) can change upwards or downwards relative to the previous catch advice (A_y). The recommended values are +20% and -30%; i.e. the catch would be limited to a maximum 20% increase or a maximum 30% decrease relative to the previous year's advised catch. The stability clause does not apply when $b < 1$. |

8.1 Choosing a multiplier (m)

For medium to faster-growing stocks with $0.32 \leq k < 0.45 \text{ yr}^{-1}$ (e.g. brill, whiting), a multiplier of $m = 0.5$ should be applied to next year's estimated catch. See Section 3.6.3 in ICES (2020a) for a justification of the multiplier.

For slower-growing stocks with $k \leq 0.32 \text{ year}^{-1}$, the chr rule might be applicable; however, this will likely require case-specific simulations to determine an appropriate target harvest rate.

For stocks for which $k \geq 0.45 \text{ year}^{-1}$, it is proposed that the method for short-lived stocks be used (Method 3), unless stock-specific simulations support the application of the chr rule.

8.2 Advice interval

Method tested with advice every year (annual).

8.3 Considerations

- Use the most recent data available (e.g. I_y instead of I_{y-1}).
- Do not change the interval (or any other parameter of the chr rule) without simulations that support it.
- The CHR rule can not technically produce zero catch advice. If the biomass index is very low, and determined by expert judgement to be below any reasonable *Blim*, then zero catch advice should be given.

9 Method 2.3: rb rule

The rb rule (Eq. 7) is a simpler version of the rfb rule and is meant to cover those cases where length data (f) are not available. This is method is a last resort and should be avoided, if possible, as it reduces catch advice over time unless the stock is increasing strongly with $r \geq 2$. The rb rule adjusts the catch advice by the trend from a biomass index but does not include a target (the f target from the rfb is not included) and has a tendency to increase risk over time. Therefore, to ensure the advice follows ICES precautionary approach, catches need to be reduced over time.

The rule is decoupled from the life history parameter k , and is tuned to ensure that the 5% risk threshold is met across a broad range of k values. It is intended as a replacement for the widely used “2-over-3” rule, for the cases where the rfb and chr rules cannot be used. The “2-over-3” rule (coupled with an uncertainty cap and precautionary buffer) has consistently been shown to deliver poor performance when compared to alternative rules (such as the rfb rule).

Collecting length data can allow moving away from the rb rule to the rfb or chr rule. A single year of length data may be enough in the first year of the application, and then additional data collection may be done on a biennial basis.

$$A_{y+1} = A_y \times r \times b \times m \tag{7}$$

Table 6 lists the data requirement for the chr rule and the components of the rb rule are presented in Table 7.

Table 6. Data requirements of the rb rule.

| Component | Details |
|-----------------------|---|
| Previous catch advice | <ul style="list-style-type: none">• See Section 6.8 for details |
| Biomass index | <ul style="list-style-type: none">• See Section 6.6 for details.• At least five years of data needed |

Table 7. Components of the rb rule.

| Component | Definition | Description and use |
|------------------|---|--|
| A_{y+1} | $A_y \times r \times b \times m$ | The advised catch for next year $y+1$ (set on a biennial basis) |
| A_y | | The most recent year's advised catch (or catch, see section "Reference catch (for rfb and rb rules)" above on p. 13). |
| r | $\frac{\sum_{i=y-2}^{y-1} (I_i/2)}{\sum_{i=y-5}^{y-3} (I_i/3)}$ | The rate of change in the biomass index (I), based on the average of the two most recent years of data ($y-2$ to $y-1$) relative to the average of the three years prior to the most recent two ($y-3$ to $y-5$), and termed the "2-over-3" rule. |
| b | $\min\left\{1, \frac{I_{y-1}}{I_{\text{trigger}}}\right\}$ | Biomass safeguard. Adjustment to reduce catch when the most recent index data I_{y-1} is less than $I_{\text{trigger}} = 1.4I_{\text{loss}}$ such that b is set equal to $I_{y-1}/I_{\text{trigger}}$. When the most recent index data I_{y-1} is greater than I_{trigger} , b is set equal to 1. I_{loss} is generally defined as the lowest observed index value for that stock. I_{trigger} may need to be adapted if the stock has been exploited only heavily or lightly in the past. |
| m | [0,1] | Multiplier applied to the harvest control rule to maintain the probability of the biomass declining below B_{lim} to no more than 5%. May range from 0 to 1.0. |
| Stability clause | $\min\{\max(0.7A_y, A_{y+1}), 1.2A_y\}$ | Asymmetric conditional stability clause. Limits the amount the advised catch (A_{y+1}) can change upwards or downwards relative to the previous catch advice (A_y). The recommended values are +20% and -30%; i.e. the catch would be limited to a maximum 20% increase or a maximum 30% decrease relative to the previous year's advised catch. The stability clause does not apply when $b < 1$. |

The use of the rb rule should be accompanied by a multiplier of $m = 0.5$, applied to the next year's estimated catch. See Section 3.6.2 in ICES (2020a) for a justification of the multiplier.

9.1 Advice interval

Method tested with advice every two years (biennial).

9.2 Considerations

- Use the most recent data available (e.g. I_y instead of I_{y-1}).
- Do not change the interval (or any other parameter of the rb rule) without simulations that support it.
- The rb rule can not technically produce zero catch advice. If the biomass index is very low, and determined by expert judgement to be below any reasonable B_{lim} , then zero catch advice should be given.
- The average of recent catches can be used as the basis of advice in the first application of the rule OR when zero advice has been given previously and the biomass index has shown a clear increasing trend.

10 Method 3: advice rules for harvest control rules for short-lived species

Given their dynamics, the risk of harvesting short-lived stocks with high interannual biomass variability is inherently greater than for longer-lived species. As such, the HCRs applied to short-lived stocks are designed in a manner that incorporates the dynamics of these specific stocks.

There is no specific definition of a “short-lived” stock. The simulations used $k \geq 0.45\text{yr}^{-1}$ (the fastest growing species such as John Dory, pilchard, herring, and sandeel).

10.1 Method 3.1: SPICT for short-lived stocks

For short-lived, data-limited stocks with sufficiently long data series and contrast in biomass and production, surplus production models can be fitted and the advice can be formulated on the basis of F_{MSY} (rather than on constant catch at MSY). Advice could also possibly be formulated on less than F_{MSY} to account for the strong fluctuations of these short-lived species (i.e., following Method 1 with the generic 35th fractile or determine a better fractile through MSE for the stock-specific case study).

Such an F_{MSY} rule would be most successful if applied to an assessment that included an indicator of the population biomass just prior to the management calendar while including most of the harvestable population age classes.

A year lag between the assessment and management years worsens the performance of the management for short-lived species, and this should be evaluated in comparison with other potential HCRs. Refer to ICES (2020a) for further details on this method and its caveats.

10.2 Method 3.2: constant harvest rate (chr) rule for short-lived stocks

If a SPiCT model cannot be fitted to a short-lived, data-limited stock, and the stock has an accepted survey, the best way to adjust catches to the highly fluctuating nature of these stocks may be to remove a constant fraction of the stock every year, corresponding with a sustainable harvest rate ($HR_{MSY,proxy}$), applicable to the abundance indicator of the stock ($I_{current}$), so that risk of falling below B_{lim} is kept < 0.05 .

$$A_{y+1} = I_{current} \cdot HR_{MSY,proxy} \quad (8)$$

The constant harvest rate HCR can be complemented with a biomass safeguard factor (b factor) based on a trigger index value, below which the advice should be corrected downwards in proportion to the drop of the most recent abundance index over the $I_{trigger}$ value.

10.2.1 Application of the method

A stock-specific MSE process should be conducted when implementing this method. The MSE should: (1) determine the constant harvest rate that is most robust to the operating model and observation system uncertainties; (2) consider the time-lag between the index availability and

management implementation; and (3) determine the $I_{trigger}$ value, aiming at assuring allowable risk levels.

10.2.2 Caveats

This constant harvest rate HCR is dependent on the actual life history of the stock and is conditioned on the survey catchability and observation error. Therefore, the degree of prior knowledge on the range of potential catchabilities and the likely magnitude of observation errors should be taken into account when considering this as a risk-averse HCR.

The application of a constant harvest rate can only be achieved for a management calendar triggered immediately after the abundance index becomes available (either from the survey or from the fishery). The longer the lag in time between the availability of the abundance index and the implementation of the management decision the lower would be the sustainable harvest rate.

10.3 Method 3.3: One-over-two rule for short-lived stocks

When knowledge of catchability and observation errors of the abundance index are so poor as to preclude the selection of a robust constant harvest rate, a HCR that determines next year's advised catch based on the last advised catch can be used.

The HCR is defined as:

$$A_{y+1} = \left\{ \begin{array}{ll} 0.2 A_y & \frac{I_y}{\sum_{y-1}^{y-2} I_y / 2} < 0.2 \\ A_y \frac{I_y}{\sum_{y-1}^{y-2} I_y / 2} & 0.2 \leq \frac{I_y}{\sum_{y-1}^{y-2} I_y / 2} < 1.8 \\ 1.8 A_y & \frac{I_y}{\sum_{y-1}^{y-2} I_y / 2} \geq 1.8 \end{array} \right\} \cdot \left[\min \left(1, \frac{I_{current}}{I_{trig}} \right) \right] \quad (9)$$

where A_y and I_y represent the advised catch and the biomass indicator for year y , respectively.

The first and third cases of the formula correspond to the application of an 80% symmetrical uncertainty cap.

The last term in the equation refers to the biomass safeguard based on a trigger index value, below which the advice would be corrected downwards in proportion to the drop of the most recent abundance index over the $I_{trigger}$ value. This is a term which has been shown to further reduce the risks associated to this management system. A recommendation is made to take $I_{trigger}$ as $I_{stat} = \text{geometric mean}(I_{hist}) \exp(-1.645 \text{sd}(\log(I_{hist})))$, where I_{hist} is the available historical series of the abundance index.

- The notation of these rules is for in-year advice where the advised catch for the current year is based on last year's advised catch adjusted by the trend in the most recent abundance index, I_y , relative to the average of the index value in the previous two years.
- An uncertainty cap is applied to limit the change in the index trend, the I_y component of the HCR, to $\pm 80\%$, which allows the current years advised catch to increase or decrease up to 80% relative to the previous years advised catch.

- Note that $\frac{I_y}{\sum_{y-2}^{y-1} I_y/2}$ should be replaced by $\frac{I_{y+1}}{\sum_y^{y+1} I_y/2}$ in the formula above if the index is available at the beginning of the management year $y+1$, instead of being available at the end of the interim (management) year y .

10.3.1 Application of the HCR

For some short-lived species, assessments are so sensitive to incoming recruitment to the fishery that information on the incoming year class is essential to assessment and management. Therefore, for these species, the management quota year should be coupled as closely as possible to the availability of the abundance index that includes the incoming recruitment. For most of the stocks concerned, such data are obtained just before the fishery starts (or during the fishing year). Therefore, the advice on fishing possibilities is often given just prior to the start of the fishing season or after the fisheries have started, which corresponds with the formulation provided above.

In the case where the survey is at the beginning of the management year, the fishery could start with a provisional catch to be updated when the abundance index is available.

The HCR for short-lived stocks consists of three components: the advised catch in the previous year, the trend in the index, and the uncertainty cap. The trend in the index performs best for short-lived stocks when the most recent years, including data from the current year, are applied. It is recommended to use the most recent year of data divided by the average of the index over the preceding two years (termed 1-over-2). The rule has been shown to perform best when a large fraction of the harvested population in the management year is covered by the index.

The first time this rule is applied to a stock, the initial catch should be taken from the mean of the catch from the previous two years (ICES, 2019b).

Short-lived stocks can show large biomass fluctuations from one year to the next. A symmetrical 80% uncertainty cap allows appropriate adjustment of the HCR accordingly from year to year. Large reductions in catch may be necessary between years to respond accordingly to reductions in the underlying stock biomass.

The precautionary buffer will certainly reduce the initial risks associated with a historic substantial exploitation of the stock (above F_{MSY}), though is probably unnecessary for lightly exploited stocks. The performance of the rule has been mainly tested without any precautionary buffer, but some simulations were conducted that used a buffer of 20% in the first year (ICES, 2021c). The application of a precautionary buffer in the first year could be considered if the stock is determined by expert judgement to be over exploited and biomass to be at a low level.

10.3.2 Caveats

This is a blind HCR as it does not necessarily lead to MSY exploitation, but it implies a decreasing trend of catch options in time after repeated applications, particularly when coupled to the 80% symmetrical uncertainty cap constraint, whereby for stocks substantially exploited (around or above F_{MSY}) it will decrease risks of falling below 20% B_0 below 0.2 in about ten years, and to levels around 0.05 or below after 20–30 years of applications (ICES, 2020a; Sanchez-Maróño *et al.* 2021). Therefore, this trend-based rule should be considered a provisional HCR with the aim of achieving a better management approach within ten years. Long-term application of this HCR may lead to major losses of yield.

For stocks that were heavily exploited in the past, the rule does not necessary lead to precautionary levels of risk in the short term, but rather it gradually leads to sustainable exploitation in the long term.

Application of the uncertainty cap can lead to major reduction of catches in the long term. It is recommended that this HCR rule be periodically re-evaluated (Sanchez-Marono *et al.*, 2021).

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Annex 1: Detailed version history

| Version | Date | Major changes |
|---------|-------------------|---|
| 3 | February/ 2025 | <p>Clarifications and changes for Method 1 (SPiCT) based on WKLIFE XIII</p> <p>Clarifications for Methods 2 without changes to the methods</p> <ul style="list-style-type: none"> Section 4, Table 1: added more details for methods. Section 4, Figure 2: updates to decision tree for selecting methods Method 1, Section 5 <ul style="list-style-type: none"> SPiCT HCR, Section 5.3: Correction to Equations 3 and 4 describing the SPiCT HCR so that it aligns with the way it is used in the SPiCT R package. SPiCT HCR, Section 5.3: Added comment that a lower fractile (15th) may be used for vulnerable species, based on the work of WKLIFE XIII SPiCT HCR, Section 5.3: Clarification that the alternative SPiCT HCR (Equation 4) can be used for accepted but more uncertain SPiCT assessments with the 35th fractile. SPiCT application, Section 5.4: Clarification that SPiCT is usually applied annual but can be applied biennially. Method 2, Section 6 <ul style="list-style-type: none"> Replaced term “uncertainty cap” with “stability clause” in line with ICES practices. Added sections 6.6 (Biomass index), 6.9 (Length data), 6.10 (Fishing proxy) with general descriptions. Method 2.1 (rfb rule), Section 7, Table 2: Moved content from table into Sections 6.6, 6.9, and 6.10 to remove redundancies. Method 2.2 (chr rule), Section 8 and Method 2.3 (rb rule), Section 9: Added Tables 4 and 6 with data requirement for the methods. |
| 2 | May/2024 | <p>Clarifications for Method 2 (Methods 2.1, 2.2, 2.3) without changes to the methods. Guidelines for other methods were not changed.</p> <ul style="list-style-type: none"> Method 2 (general text), Section 6 <ul style="list-style-type: none"> Reference added to Fischer <i>et al.</i> (2022) for testing of chr rule. “Stock-specific application”, Section 6.2: Reference added to Fischer <i>et al.</i> (2023) as example for stock-specific tuning and reference to WKLIFE XI (ICES, 2023) for recommendations on stock-specific tuning. “Multiplier (m)”, Section 6.3: Clarification that multiplier does not lead to continuous reduction of advice value for rfb and chr rules. “Advice interval”, Section 6.5: Paragraph added explaining that WKLIFE looked at impact of changes to advice interval. Section 6.8, “Reference catch (rfb and chr rules)”, added: Clarification that reference catch can be realised catch for first application of methods. Section 6.11, “Reference values and updates”, added: Clarification that reference values should not be updated every year. Section 6.12, “Software”, added: Reference added to R package cat3advice. Method 2.1 (rfb rule), Section 7 <ul style="list-style-type: none"> Table 2 and Table 3: Clarification that reference catch can be based on catch. Table 2, length data: Clarification that reference values such as L_c should ideally be calculated with pooled data from several years. Method 2.3 (rb rule), Section 9 <ul style="list-style-type: none"> Clarification that collecting length data can allow use of rfb or chr rules instead |

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| | | <div>of rb rule.</div> <div><div>○ Table 5: Clarification that reference catch can be based on catch.</div><div><div>• Background, Section 3; and Applying the advice rules – how to get started, Section 4, and Table 1</div><div><div>○ Reference to the possibility of zero catch advice for stocks with low biomass was included in Section 3 and 4 and in Table 1.</div><div>○ Figure 2: Zero catch option added to diagram.</div></div></div></div> |
| 1 | May/2022 | Guidelines established |