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EU request to provide guidance on operational methods for the evaluation of the MSFD criterion D3C3 (second stage 2017)

Advice summary

ICES advises that the data currently collected on fish length for stock assessment purposes is suitable to assess the size distribution of a stock. ICES advises that there is a need to further test three potential indicators for D3C3 (the age and size distribution of individuals within commercially exploited stocks) that focus on the large spawning fish within each considered stock. To derive reference levels and possible assessment thresholds, population models can be used to simulate fishing scenarios in accordance with good environmental status under D3C1 and D3C2. In a second stage, the age-based indicator concepts could be transferred to size-based calculations to enable a wider application to those stocks that do not have ageing information.

Until the proof of concept has been validated, ICES recommends that D3C3 be considered as a surveillance indicator for size distribution and that several time-series assessment methods may be appropriate to track relative changes in the indicator metrics.

Request

Guidance on development of operational methods for the evaluation of the MSFD criterion D3.3 (The second stage of 2017)

In light of the recent ICES MSFD guidance on operational methods for the evaluation of the MSFD Criterion D3C3 (http://www.ices.dk/sites/pub/Publication%20Reports/Advice/2016/Special_Requests/EU_Guidance_on_MSFD_criterion_33.pdf) that concluded that the indicators are currently neither operational nor fit for the purpose of the assessment of good environmental status (GES), the a succeeding technical service was adapted. With a workshop aimed to further explore D3C3 methods, ICES was requested to develop methods to describe the size distribution of a stock. The exploration will focus on:

a) the data requirements to assess the size distribution of a stock
b) potential size-based indicators (SBI) that are not redundant to D3C1 and D3C2
c) methods to describe the trend over time in SBI
d) the setting of thresholds and reference levels for any potential methods

Elaboration on the advice

ICES convened a workshop in November 2016 at ICES Headquarters in Copenhagen, Denmark to answer the European Commission's request to provide guidance on the development of operational methods for the evaluation of the MSFD criterion D3C3.

Results

a) the data requirements to assess the size (or age) distribution of a stock

Table 1 indicates four potential size-based indicators and their data requirements for individual stocks. The data needed to derive these indicators are already collected for stock assessment purposes, either during fish surveys or through commercial catch sampling.

Size-based indicators (SBIs) were originally considered to be best suited for indicators of D3C3 because they can be calculated for a wide range of stocks. However, as suggested by Commission Decision EU/2010/477 (EC, 2010), ICES recommends that age-based indicators (ABIs) should be used for D3C3 where possible. The advantage of ABIs over SBIs is that they can be readily calculated from age-based stock assessment outputs, thereby creating longer time series than is possible when using only data

from fisheries surveys. Furthermore, ABIs based on stock assessment outputs ensure consistency between calculation methods and data sources for indicators of criteria D3C1, D3C2, and D3C3.

In the absence of stock age frequency distributions (AFDs) from stock assessment, SBIs calculated from survey length frequency distributions (LFDs) should be considered.

Once the feasibility of the age-based indicators has been demonstrated, methods for translating these indicators into size-based metrics need to be developed to ensure wider applicability.

Table 1 Overview of data requirements to assess SBI (AFDs: Age frequency distributions; LFDs: length frequency distributions). Annex 2 provides a key to the symbols and abbreviations used in this advice.

INDICATOR	DATA REQUIREMENTS	OBJECTIVE	STATUS	RELEVANCE TO MSFD
B_{large} or N_{large} (related to SSB_{mega} or $CPUE_{mega}$)	AFD from stock assessments. If no stock assessment data are available, LFD from the survey data should be used.	Assess the absolute abundance of large spawners	Further development and testing required	D3C3
P_{large} (related to P_{mega})	AFD from stock assessments. If no stock assessment data are available, LFD from the survey data should be used.	Assess the relative abundance of large spawners	Further development and testing required	D3C3
L_{95}	Converted AFD to LFD from stock assessments. If no stock assessment data are available, LFD from the survey data should be used.	Assess the size distribution within a stock	Further development and testing required	D3C3
L_c and L_{mean}	LFD of commercial catch.	Assess the selectivity pattern of the fishery	Operational	-

The P_{mat} suggested as an SBI in the proposed revision of EC (2010) should not be further pursued because it is highly sensitive to recruitment and is not linked to the large spawners component of fish stocks.

b) potential size-based indicators (SBIs) that are not redundant to D3C1 and D3C2

In many (but not all) fish stocks, large spawners (also referred to as megaspawners or repeat time spawners) are needed to ensure high productivity of the stock. In addition, large fish are important for ecosystem structure and function. Indicators of D3C2 (SSB) do not directly account for these aspects of fish stock status. Potential size- or age-based indicators used within D3C3 should therefore focus on the component of large spawners in the stock.

In the absence of an agreed biological definition of a large spawner, ICES advises that a division value of the large individuals within a stock should be used initially (e.g. Figure 1). Variation between stocks in their growth and maturity prevent a generic approach to determining where this division value lies, which means a stock-by-stock (or possibly by functional group, i.e. demersal, pelagic, etc.) analysis is required. Proximity between the division value and L_{mat} (length at which 50% fish are mature) should be avoided to make the component of large spawners distinct from the component of spawners. The concept could be also applied to age frequencies if these are known for a stock.

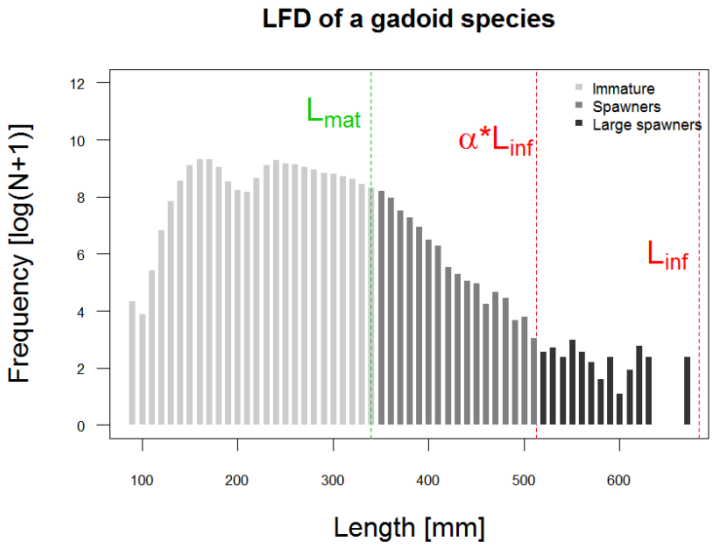

Figure 1 A generic length frequency distribution of a gadoid with truncated size structure. Shading represents different components of the stock (immature, spawners, large spawners). Life history parameters like L_{inf} or L_{mat} can be used to define the component of large spawners, e.g. by using a fraction of L_{inf} as a division value α which is stock specific.

The L_{95} also aims to characterize the abundance of large individuals; however, it is not directly related to any biological concept. In the absence of information on life-history parameters such as maximum size or size-at-first-maturity, the L_{95} may be used as a proxy for P_{large}, N_{large}, or B_{large}. However, as this indicator is sensitive to the abundance of small fish, for example through a large recruitment of young fish to the spawning component of the stock, it needs to be tested if the indicator trajectories of L_{95}, P_{large}, and N_{large} or B_{large} are similar and yield comparable assessment results.

Sized-based indicators of commercial catches (L_c and L_{mean}) were demonstrated to be operational for a wide variety of stocks. These indicators can be used to monitor selectivity in fishing practices.

Simulated populations representing different life-history strategies and fishing regimes (including selectivity) may provide better insights into influences of fishing intensity and selectivity on stock size and structure. Simulations or analyses of existing data series are needed to better understand the impact of fishing on indicators of D3C3 and the relationships between indicators of D3C1, D3C2, and D3C3.

c) methods to describe the trend over time in SBI

Many methods based on time-series are available, suited for all kinds of data situations (Annex 1). Time-based methods can track relative changes of indicators, but it is uncertain how they relate to good environmental status (GES).

d) setting of thresholds and reference levels for any potential methods.

It was not possible to develop a generic concept to identify stock-specific reference values that indicate GES for the size-based indicator in question.

However, when available, population models can be used to determine potential reference values for SBIs considered in point b) above. For each stock, the reference value of the indicator could be based on simulations of the fish size distribution following a period of long-term exploitation at F_{MSY} (Figure 2).

Proof of concept strategy

A possible way forward in the delivery of D3C3 operational indicators with thresholds would be a proof of concept strategy, establishing a routine for assessing the size distribution over a suite of selected stocks with analytical assessments that are at F_{MSY} and at or above MSY $B_{trigger}$ (e.g. northern hake, North Sea plaice, Arctic cod, North Sea herring).

Both the ABI and the SBI reference values should be reviewed periodically to account for changes in growth and mortality caused by interspecific and density-dependent interactions. These changes may be expected to increase as the abundance of other ecosystem components change.

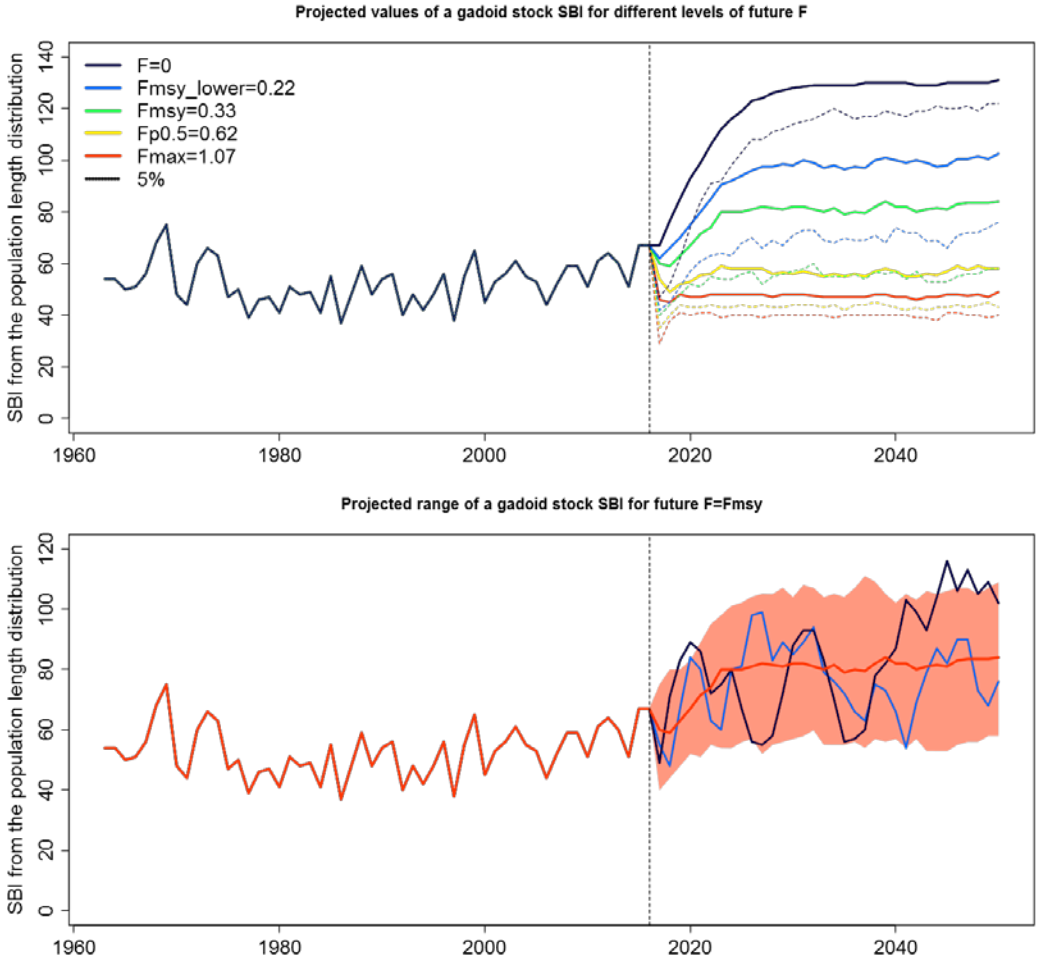

Figure 2 Top: A size-based indicator (SBI) calculated from modelled population length distributions for a simulated gadoid stock for a range of different future F scenarios: no fishing (F = 0), fishing at the boundary of the F_{MSY} range (F_{MSY_lower}), fishing at F_{MSY} (F_{MSY}), fishing at an F to ensure less than 5% probability of SSB dropping below safe biological limits ($F_{p0.5}$), and fishing at F_{max} based on yield-per-recruit (F_{max}). Median values (solid lines) and lower 5th percentiles (dashed lines) are shown. Bottom: Simulated future range of the SBI when fishing at F = F_{MSY}. Median values (solid red line), 95% ranges (red shaded area), and two example iterations (black and blue lines) are shown.

ICES considers that it is not possible to set biologically meaningful threshold or reference values of either ABI or SBI using time-series methods. Such thresholds or reference values would allow comparison of current indicator values with past values, but they cannot account for interactions within and between stocks that might occur when fishing consistently at F_{MSY}.

Additional information

In 2016, ICES recommended that the assessment of good environmental status for descriptor D3 should focus on indicators for criteria D3C1 and D3C2. It is still not resolved whether age- or size-based indicators for D3C3 contain redundancy with respect to D3C2. This question can be addressed when analysing the relationship between indicators of D3C2 and D3C3 for stocks being fished at F_{MSY} (see the proof of concept strategy above). In the meantime, D3C3 should be considered as a surveillance indicator to ensure that any deterioration in the state of the stock would be detected.

As in 2016, ICES recommends the use of selectivity indicators for surveillance purposes.

Sources and references

EC. 2010. COMMISSION DECISION of 1 September 2010 on criteria and methodological standards on good environmental status of marine waters (notified under document C(2010) 5956). (Text with EEA relevance). (2010/477/EU). Official Journal of the European Union, L 232/14.

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Annexes

Annex 1 Strengths and weaknesses of the methods used to analyse indicator time-series.

METHOD	STRENGTHS	WEAKNESSES
Trend analysis	• Easy to apply • Range of methods available (linear/polynomial regression, generalized additive model) • Applicable with short time-series • Smoothing can reduce variability	• Reference points are not used • Older data are not used if only recent trends are assessed • Cannot establish if GES has been attained • Trends cannot be indefinitely unidirectional
Simple statistics (means, quantiles of time-series)	• Can be applied with short time-series	• Cannot establish if GES has been attained
Advanced statistics (breakpoint analysis, dynamic methods)	• Evaluates changes in indicators over time • Smoothing accounts for variability in indicator over time • The methods may be used to establish reference points • Relevant software is generally available	• Expertise required for some statistical methods • Requires longer and continuous time-series • Length of time-series and model specification can affect analysis • Cannot establish if GES has been attained

Annex 2 Key to symbols and abbreviations used in this advice.

SYMBOL/ACRONYM	KEY
ABI	Age-based indicator.
AFD	Age frequency distribution. An AFD can be estimated either from catch or survey data, or from a model estimate of the whole population.
B_{large}	Biomass of large fish in the stock. Related to SSB_{mega} and $CPUE_{mega}$.
$CPUE_{mega}$	The catch per unit effort of megaspawners in the catch or a survey. Megaspawners have been defined as spawners longer than L_{mega} (= 1.1 × L_{opt}).
D3C1, D3C2, and D3C3	Three criteria under Descriptor 3 of the EU's Marine Strategy Framework Directive, referring to commercial fish and shellfish stocks. D3C1 refers to stocks being exploited sustainably in a way that is consistent with high long-term yields; D3C2 refers to stocks having full reproductive capacity in order to maintain stock biomass; D3C3 refers to the proportion of older and larger fish/shellfish being maintained (or increased), this being an indicator of a healthy stock.
F	Fishing mortality. The rate of mortality in the stock as a result of fishing.
F_{max}	The fishing mortality rate that maximizes equilibrium yield-per-recruit. F_{max} is the F level often used to define growth overfishing (when fish are harvested at an average size that is smaller than the size that would produce the maximum yield-per-recruit).
F_{MSY}	The F expected to give maximum sustainable yield in the long term.
F_{MSY_lower}	The lower end of the F_{MSY} range, derived to deliver no more than a 5% reduction in long-term yield compared with MSY.
$F_{p0.5}$	The upper F limit that is considered precautionary for management plans and MSY rules.
L_{95}	The 95th percentile of a length distribution.
L_c	The length at which fish are first vulnerable to capture by the fishery.
L_{inf}	A von Bertalanffy growth model parameter, expressing the asymptotic length. i.e. the mean length the fish in a population or stock would reach if they were to grow indefinitely. This is often close to the length of very old fishes.
L_{mat}	The length at which 50% of fish are mature.

SYMBOL/ACRONYM	KEY
L_{mean}	The mean length of fish.
L_{mega}	The theoretical length above which fish are considered to be 'megaspawners'. Defined as 10% above L_{opt}.
L_{opt}	The theoretical length at which an unfished cohort reaches maximum biomass, approximately $^2/_3$ of L_{inf}.
LFD	Length frequency distribution. An LFD can be estimated either from catch or survey data, or from a model estimate of the whole population.
MSY	Maximum sustainable yield. The largest average catch or yield that can continuously be taken from a stock under the existing environmental conditions.
MSY $B_{trigger}$	A lower bound to the SSB when the stock is fished at F_{MSY}. If the SSB of the stock is below this point, F is reduced when applying the ICES MSY advice rule.
N_{large}	Abundance (N) of large fish in the stock.
P_{large}	The proportion of large fish in the stock catch, index, or population. Related to P_{mega}.
P_{mat}	The proportion of mature fish in the stock catch, index, or population.
P_{mega}	The proportion of megaspawners in the stock catch, index, or population.
SBI	Size-based indicator (i.e. based on length).
SSB	Spawning-stock biomass. Total mass of all sexually mature fish in the stock.
SSB_{mega}	The SSB of megaspawners in the stock catch/index/population. Megaspawners are defined as spawners longer than L_{mega} (= 1.1 × L_{opt}).