ICES Special Request Advice
Arctic Ocean, Barents Sea, and Norwegian Sea ecoregions
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Norwegian request for evaluation of management of Norwegian coastal cod north of 67° N

Advice summary

ICES advises that an appropriate B_{lim} to be used as a basis for ICES Advice Rule cannot be identified with the currently available data for this stock. As a consequence of this, the proposed harvest control rule (HCR) and rebuilding plan are not considered consistent with the precautionary approach or ICES MSY approach.

ICES further advises that a precautionary HCR for the stock is a fishing mortality of $F_{0.1}$, a conservative proxy for F_{MSY}, applied at all stock sizes above B_{loss} (minimum observed spawning-stock biomass [SSB]).

Request

ICES received the following request from Norway on 23 December 2021:

In order to provide scientific underpinnings for management of Norwegian coastal cod north of 67° N (cod27.1-2coastN), Norway requests ICES to produce and evaluate a Harvest Control Rule (HCR) and (if required) a rebuilding plan by February 15, 2022 as follows:

- *As part of the evaluation procedure, among potential B_{lim} candidates/definitions, identify the appropriate one to be used as the target biomass for recovery of coastal cod north of 67° N*
- *Evaluate if the defined age range for calculating the fishing mortality adequately represents fisheries pressure on the stock (the so called "F-bar" range)*
- *Rebuilding Plan: If SSB is currently below B_{lim}, evaluate the fishing pressure required to result in a 95% chance for SSB to reach B_{lim} in a given time frame including a) twice the time that it would take to be 95% likely for SSB to be above B_{lim} with zero fishery (2*TMIN), b) the time of one generation (approximately 5 years) plus the time that it would take to be 95% likely for SSB to be above B_{lim} with zero fishery (one generation + TMIN).*
- *Harvest Control Rule: Given the bycatch nature of the coastal cod fishery, ICES shall evaluate a precautionary HCR for advice when above B_{lim} giving the fishing level for two catch options: one which corresponds to the maximum fishing leading to MSY (F_{MSY}) and one which corresponds to the maximum precautionary fishing level (Fp0.5)*

Other supplementary information to assist the interpretation of the request:

- *At a benchmark in 2021(WKBARFAR 2021), the Norwegian coastal cod stock north of 62° N was split into two stocks: north and south of 67° N. ICES advice for the Norwegian coastal cod stock before it was split into two stocks was based on the Norwegian rebuilding plan, which is not considered applicable to the new stock units. ICES recommends the development of a rebuilding plan for this stock.*
- *This stock is fished largely as bycatch and recreational fisheries, and consequently there is no requirement for the stock to managed to produce Maximum Sustainable Yield. Therefore, there is a requirement for a tailored HCR in place of the standard MSY-based ICES default HCR to support the management of this non-directed fishery in a precautionary manner.*
- *As part of any Harvest Control Rule evaluation process, the reference points should be evaluated. In this case there is currently no F_{MSY} reference point and a re-evaluation of the biomass limit B_{lim} was specifically recommended at WKBARFAR 2021.*

Elaboration of the advice

To answer the request, ICES re-evaluated the biological reference points and evaluated the proposed HCR and recovery plan.

Due to a high sensitivity in B_{lim} towards small changes in the assessment model, and a narrow range between the estimated F_{MSY} and F_{lim} that would require unrealistically low implementation error, it was concluded that B_{lim} could not be set with a level of certainty required to use it as a basis for simulating fishing mortality reference points. Following from this, the proposed HCR and recovery plan based on ICES Advice Rule could not be evaluated as being precautionary.

ICES conducted additional investigations into a possible alternative HCR that does not rely on the uncertain B_{lim} estimate. Long-term simulations accounting for potential forecast errors indicated that a constant fishing mortality HCR with $F_{target} = F_{0.1}$ was robust to the small changes in the assessment model that caused large changes to B_{lim}.

ICES considers management to be precautionary when populations are maintained within safe biological limits. The estimated $F_{0.1}$ level was below any of the F_{P05} levels accounting for the uncertainty in B_{lim} (lowest to highest observed SSB). Therefore $F_{0.1}$ has less than a 5% chance of driving the stock below any potential B_{lim}. The $F_{0.1}$ HCR was regarded as precautionary for the observed range of stock sizes given both its theoretical basis and that fishing mortalities close to $F_{0.1}$ have resulted in swift growth of the stock in the past.

It should be noted that the $F_{0.1}$ value is very close to the F_{P05} if B_{lim} were set at the highest observed stock size (2003–2020) and that the HCR proposed here, therefore, comes close to the F_{P05} advice mentioned in the request.

$SSB_{lowerbound} = B_{loss}$ (the lowest observed SSB) was defined as the limit of spawning-stock biomass below which $F_{0.1}$ may no longer be precautionary. The uncertainty around the level of B_{lim} is too high for B_{loss} to be used as the basis for an F_{MSY} estimate in the standard ICES Advice Rule and does not necessarily reflect the point below which recruitment is impaired.

Reference points for use in the $F_{0.1}$ HCR are presented in Table 1. If this HCR is not adopted by managers, the alternative is to retain the current procedure as defined at the last benchmark.

Table 1 Cod in subareas 1 and 2 north of 67°N, northern Norwegian coastal cod. Reference points, values, and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$	Not defined		
	F_{MSY}	Not defined		
Precautionary approach	B_{lim}	Not defined		
	B_{pa}	Not defined		
	F_{lim}	Not defined		
	F_{pa}	Not defined		
Management plan	$SSB_{lowerbound}$	67 743	B_{loss} 2003–2020 as estimated at 2022 workshop on evaluation of reference points and HCRs with 1994–2020 data. Used only as the limit above which the management plan is considered precautionary.	ICES (2022a)
	F_{mgt}	0.176	$F_{0.1}$ as estimated at 2022 workshop on evaluation of reference points and harvest control rules (WKNCCHCR) with 1994–2020 data.	ICES (2022a)

Basis of the advice

Background

The request from Norway to ICES followed a benchmark assessment in 2021 in which new stock definitions were agreed for Norwegian coastal cod (ICES, 2021). The stock was split into two units, and the northern stock was moved from category 3 to category 1 with a SAM assessment. Because of this change, there was a need to produce an HCR for the new stock. In addition, a clear recommendation from the benchmark was to further evaluate B_{lim} given high uncertainty around the value set for this reference point at the benchmark. The ICES workshop that was convened in response to the Norwegian request (on the evaluation of northern Norwegian coastal cod harvest rules [WKNCCHCR]) therefore covered both an examination of the model and data relevant to B_{lim}, as well as an HCR evaluation (ICES, 2022a).

Results and conclusions[†]

B_{lim} was highly sensitive to small changes in model settings and data and even to the choice of recruitment at age 2 versus at age 3. These changes moved the B_{lim} estimate in a range between the lowest and highest observed SSB and various points in between. Over the observed range of SSB, recruitment has never been near zero, but it is difficult to distinguish to what extent, if any, recruitment has been impaired. This is taken to imply that the signal in the recruitment is weak not only because of the noise in the data but also because of the nature of the stock as a complex of interacting substocks (various fjord substocks plus a separation-by-distance genetic gradient along the coast), meaning that there is no one single B_{lim} value associated with impaired recruitment for all of the substocks. As a result, it was concluded that no reliable B_{lim} estimate could be produced for this stock following standard ICES procedures.

As part of the work on B_{lim}, WKNCCHCR identified that the acoustic survey has poor cohort consistency, particularly in the most recent portion (the index is split between 2002 and 2003 as a result of a change in methodology). The decision was therefore taken to use the acoustic index as a biomass index instead of an age-structured index. This change has only had a minor impact on the SSB estimates but does impact the shape of the stock–recruit relationship, which is one of the reasons that the B_{lim} estimate was considered unreliable.

The request required an examination of HCRs with a combination of $B_{trigger}$ and both F_{MSY}- and F_{P05}(F_{pa})-based fishing advice. However, given the absence of a reliable B_{lim} level above which the stock should be maintained, it was concluded that none of these HCRs could be considered precautionary and therefore could not be used as the basis for ICES advice.

In order to arrive at an HCR which could be evaluated as precautionary and form a basis for potential ICES advice, WKNCCHCR proposed an HCR based on $F_{0.1}$. In addition to the theoretical basis for $F_{0.1}$ as a fishing level that should drive the stock to safe and productive levels, the $F_{0.1}$ estimate was rather stable to the range of data and model options tested at the workshop, and the stock had previously increased at similar fishing pressures. In addition, there was no evidence of the stock experiencing severely impaired recruitment in the past (in an exploratory time series back to 1977). The estimated $F_{0.1}$ level was below any of the F_{P05} levels accounting for the uncertainty in B_{lim} (lowest to highest observed SSB). Therefore $F_{0.1}$ has less than a 5% chance of driving the stock below any potential B_{lim}. The HCR with $F_{target} = F_{0.1}$ was therefore considered to be precautionary within the observed SSB range. $SSB_{lowerbound}$ was set at the lowest observed stock size in the period 2003-2020. This was done with the condition that in order to be part of a precautionary HCR, it could only be used alongside the identified $F_{0.1}$ as the F_{target} where the $SSB_{lowerbound}$ would serve as a limit on SSB below which the HCR may no longer be precautionary (requiring a new HCR). That is, the $SSB_{lowerbound}$ would not form the B_{lim} for an F_{MSY}-based HCR.

The meeting also examined the mean F age range (F_{bar}) used for reporting F and concluded that the F_{bar} range should be expanded from the current $F_{4–7}$ to $F_{4–8}$ because of increasing proportions of age 8 fish in the catch. It was further concluded that recruitment to the stock should be considered at age 3 rather than age 2 given uncertainties in the age 2 survey data. However, age 2 data should remain in the model.

Figure 1 shows the results of long-term simulations of equilibrium yield and SSB at a range of fishing mortalities (including the indicated $F_{0.1}$) based on the updated assessment model.

[†] Version 2: Clarifying text added to the fourth paragraph of Results and Conclusions indicating that the historic recruitment series was exploratory only and $SSB_{lowerbound}$ was chosen from the period 2003-2020.

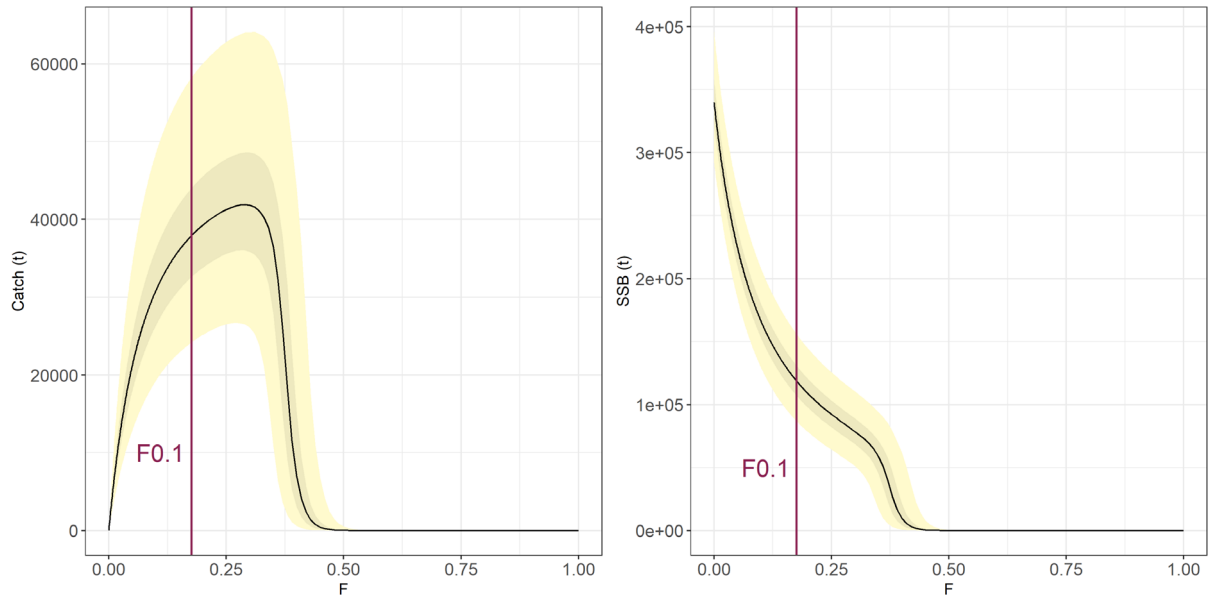

Figure 1 Cod in subareas 1 and 2 north of 67°N. Equilibrium catches (tonnes; left panel) and SSB (tonnes; right panel) as a function of fishing mortality. The solid black line indicates the median of the predicted distribution, while the dark and light-yellow fields indicate the 25–75% and 2.5–97.5% percentiles, respectively. $F_{0.1}$ = 0.176 is indicated by the vertical line.

Methods

The investigation into B_{lim} included 1) an evaluation of the tuning data to ensure that the estimated stock–recruit relationship has a sound basis, 2) an evaluation of the sensitivity of B_{lim} and other reference points to different tuning data inputs and age at recruitment, and 3) an extension of the assessment model back in time to identify whether recruitment has been impaired in the past. In addition, the current F_{bar} range was evaluated and the requested HCR options simulated. The recovery plan request was conditioned on the stock currently being below B_{lim} and was not pursued further given the lack of a reliable B_{lim} estimate.

HCR simulation

A shortcut management strategy evaluation (MSE) was conducted for northern Norwegian coastal cod using the EqSim software (ICES, 2014). The operating model was conditioned on ICES stock assessment. Future selectivity, maturity-at-age, and weight-at-age were set to the average of the last five years in the assessment. Recruitment was resampled from the last ten years rather than the entire time-series because of higher uncertainty around model estimates in the earlier period. A shortcut approach to generating assessment and forecast errors was used (ICES, 2020). The advice error of the fishing mortality was assigned a CV of 0.212, based on the default error suggested by ICES (2014). The advice error was autocorrelated to emulate observed sequential periods of over or underestimation of stock biomass using the default value of 0.423.

In the simulations, a hockey stick stock–recruit function was applied by first fitting a segmented regression to find the breakpoint (if any) in the stock–recruit relationship. The sensitivity of the reference points to different model configurations (treatment of survey data and age-at-recruitment) and the performance of the different (implied) HCRs were investigated by running multiple simulations based on different model configurations.

Sources and references

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Download the stock assessment data and figures.

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