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EU/Norway request to ICES on evaluation of long-term management strategies for Norway pout in ICES Subarea 4 (North Sea) and Division 3.a (Skagerrak–Kattegat)

Advice summary

ICES has evaluated a range of harvest control rules (HCRs) within the escapement strategy presently used for Norway pout, with additional lower (TAC_{min}) and upper (TAC_{max}) bounds on TAC and optional use of upper fishing mortality values (F_{cap}). Several HCRs were identified that combined TAC_{min} in the range of 20 000–40 000 tonnes and TAC_{max} less than or equal to 200 000 tonnes, resulting in no more than a 5% probability of the spawning-stock biomass falling below B_{lim}.

The identified combinations of TAC_{min}, TAC_{max}, and F_{cap} give a less variable TAC and F from one year to the next, but also a lower long-term yield than the default escapement strategy. ICES is not in position to advise on this trade-off between higher yield and stability.

The evaluation showed that the current procedure for providing TAC advice for Norway pout, based on an escapement strategy is only precautionary with the addition of an F_{cap} at 0.7.

Request

The European Union and Norway jointly request ICES to advise on the management of Norway Pout in ICES Subarea IV (North Sea) and ICES Division IIIa (Skagerrak-Kattegat). The proposed management strategy is based on the ICES escapement strategy for Norway pout with the aim of achieving a high probability of having the minimum SSB required to produce MSY (Blim) surviving to the following year.
ICES is requested to evaluate:

1. *Whether a management strategy is precautionary if the TAC is constrained with a lower bound in the range of 20,000 tonnes to 40,000 tonnes and an upper bound in the range of 150,000 tonnes to 250,000 tonnes, or another range suggested by ICES.*
2. *Whether such a strategy would be precautionary if the TAC constraints referred to in paragraph 1 are overridden by a constraint on the maximum value of fishing mortality (Fcap), and whether the application of the Fcap would allow a precautionary strategy with a higher minimum TAC than if the Fcap was not applied.*
3. *Whether a provision to override the minimum value of the TAC when the stock is forecast to be below some threshold value would allow a precautionary strategy with a higher minimum TAC than if the escape-clause was not included, and whether such a provision would provide any additional benefit to the inclusion of an Fcap as referred to in paragraph 2.*

ICES is requested to indicate the results of the evaluation in a table that shows for the combination of parameter values selected for the evaluation:

- *The average inter-annual TAC variation*
- *The average yield*
- *The average fishing mortality*
- *The average escapement biomass*
- *The probability that the stock falls below Blim in the year following the fishing year over a 20 year period.*

ICES is additionally asked to indicate whether the results of the evaluation are significantly changed if the TAC year is defined as 1 November to 31 October rather than a calendar year.

Elaboration on the advice

ICES has evaluated harvest control rules (HCRs) within the escapement strategy presently used (aimed at retaining a minimum stock size in the sea every year after fishing) that are restricted by a combination of TAC lower bounds (TAC_{min}) and upper bounds (TAC_{max}). For some HCRs, an upper limit on F (F_{cap}) is also used for setting the TAC.

Because of uncertainties in the estimate of the incoming year class, escapement strategies for short-lived species, where catch opportunities are very dependent on the strength of the incoming year class, may lead to a TAC where a too high portion is caught. ICES evaluations were conditioned by a maximum realized level of fishing mortality the fishery can exert (assumed at 0.89; $F_{historical}$), which means that the full TAC will not be taken if the required F to catch the TAC exceeds this value.

Request part 1

ICES has evaluated harvest control rules (HCRs) within the presently used escapement strategies, bounded by a combination of TAC_{min} (at either 20 000, 30 000, or 40 000 tonnes) and TAC_{max} (at 150 000 and 200 000 tonnes). Table 1 summarizes the long-term (2023–2037) performance metrics for the (precautionary) combinations that result in no more than 5% probability of SSB falling below B_{lim} in the period 2023–2037. More detailed statistics for both precautionary and non-precautionary HCRs are shown in Table 4.

Table 1 Long-term summary statistics for precautionary request part 1 HCRs with application of TAC_{min} and TAC_{max}, but no F_{cap}.

Scenario*	TAC_{min} (tonnes)	TAC_{max} (tonnes)	Long-term P(SSB< B_{lim}) (%)	TAC median (tonnes)	TAC mean (tonnes)	TAC change (tonnes)	At $F_{historical}$ (%)	At TAC_{min} (%)	At TAC_{max} (%)
3	20000	150000	3.74	130054	99597	49911	9.1	20.8	46.0
4	20000	200000	3.94	123299	118119	69988	16.4	21.7	36.4
5	30000	150000	4.86	128023	101179	44950	9.6	24.6	45.7

* See Table 4.

The precautionary HCR scenarios resulted in median TACs of 123 000–130 000 tonnes and mean TACs at 100 000–118 000 tonnes. The changes in TAC between years are high, around half of the mean TAC for the HCR. Figure 1 shows the distribution of TAC and mean F for one HCR where it is seen that TAC in an individual year is often bounded by the TAC_{min} and TAC_{max} values. The probability of a TAC at TAC_{min} (20 000 tonnes) is 20.8% and the probability of a TAC at TAC_{max} (150 000 tonnes) is 46.0%. This skewed TAC distribution gives a large difference between the median TAC and the mean TAC, and explains also the large differences in TAC (49 000 tonnes) for the individual years. The mean F is more evenly distributed, albeit distributed over a large interval of time. The Norway pout fishery shows a good relationship between fishing effort and fishing mortality. The presented distribution of mean F does therefore indicate a rather variable fishing effort from one year to the next. $F_{historical}$ is reached in 9–16% of the years for all the precautionary HCR scenarios, which makes the results sensitive to the assumption that the fishery stops catching Norway pout when F exceeds $F_{historical}$. Therefore, the HCR should be re-evaluated if future F exceeds $F_{historical}$ (0.89).

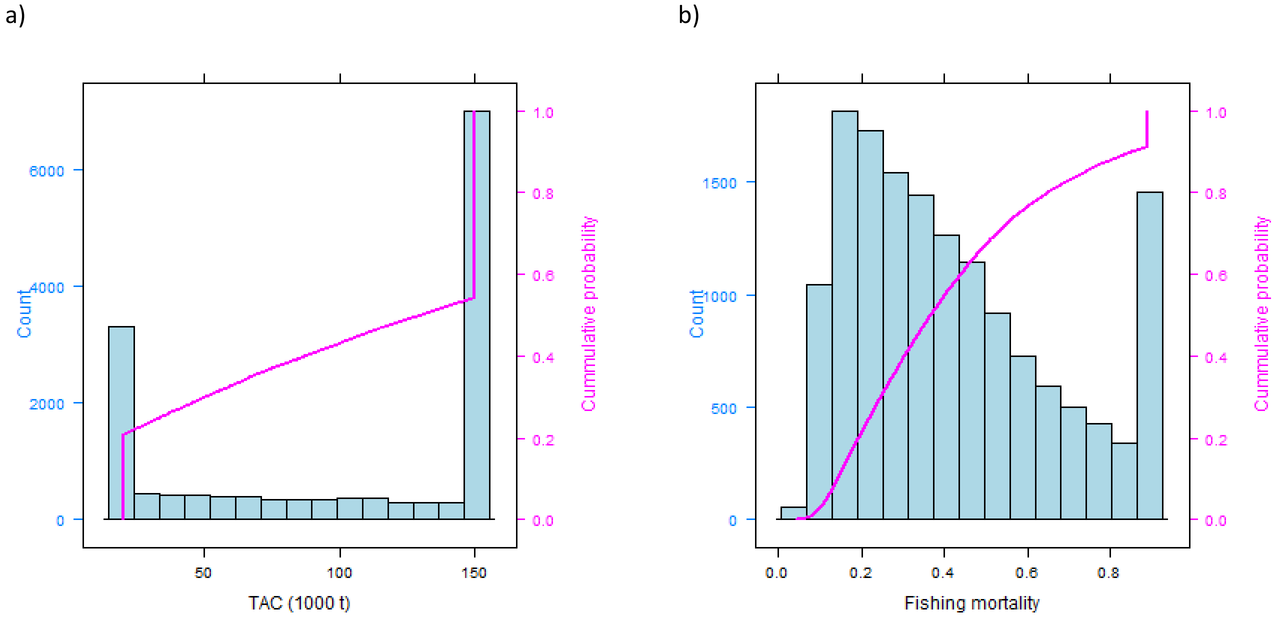

Figure 1 Long-term distribution of a) TAC and b) mean F from the HCR in the request part 1, with TAC_{min} at 20 000 tonnes and TAC_{max} at 150 000 tonnes.

Request part 2

ICES evaluated the same combinations of TAC_{min} and TAC_{max} as for the request part 1, with F_{cap} at either 0.3 or 0.4. A wider range of HCRs with combinations of TAC_{min} and TAC_{max} become precautionary when they are combined with an F_{cap} in the range of 0.3 to 0.4.

Table 2 shows the summary statistics for the precautionary HCRs, Table 4 shows the results for all the evaluated HCRs.

The probability of setting a TAC at TAC_{min} is similar to the probability for HCRs without an F_{cap}, but the probability of reaching TAC_{max} becomes considerably lower when F_{cap} is applied. The absolute changes in TAC between years are smaller when F_{cap} is applied, partly because of the lower TAC in general. The TAC examples for the HCR in the request part 2 (Figure 2) show a more even distribution of TAC than for the HCR without F_{cap} (Figure 1).

Applying F_{cap} makes the HCR robust to the assumption of an $F_{historical}$, as the probabilities of reaching $F_{historical}$ become significantly lower (max 3.1%) than for the HCR without an F_{cap} (max $F_{historical}$ at 16.4%).

Table 2 Long-term summary statistics for precautionary HCRs in the request part 2, applying TAC_{min}, TAC_{max}, and F_{cap}.

Scenario*	F_{cap}	TAC_{min} (tonnes)	TAC_{max} (tonnes)	Long-term P(SSB< B_{lim}) (%)	TAC median (tonnes)	TAC mean (tonnes)	TAC change (tonnes)	At $F_{historical}$ (%)	At TAC_{min} (%)	At TAC_{max} (%)
13	0.3	20000	150000	3.17	72265	77453	39497	0.7	19.1	14.3
14	0.4	20000	150000	3.55	89742	87686	42865	2.2	20.1	23.4
15	0.3	20000	200000	3.19	71968	81944	47072	0.9	19.2	6.7
16	0.4	20000	200000	3.61	88465	95345	54578	3.1	20.4	12.4
20	0.3	30000	150000	4.14	71706	79107	36744	0.8	22.9	14.2
21	0.4	30000	150000	4.55	89236	89391	40005	2.7	23.8	23.2
22	0.3	30000	200000	4.17	71367	83574	44260	1.4	23.1	6.6
23	0.4	30000	200000	4.67	88057	97107	51715	3.6	24.2	12.3

* See Table 4.

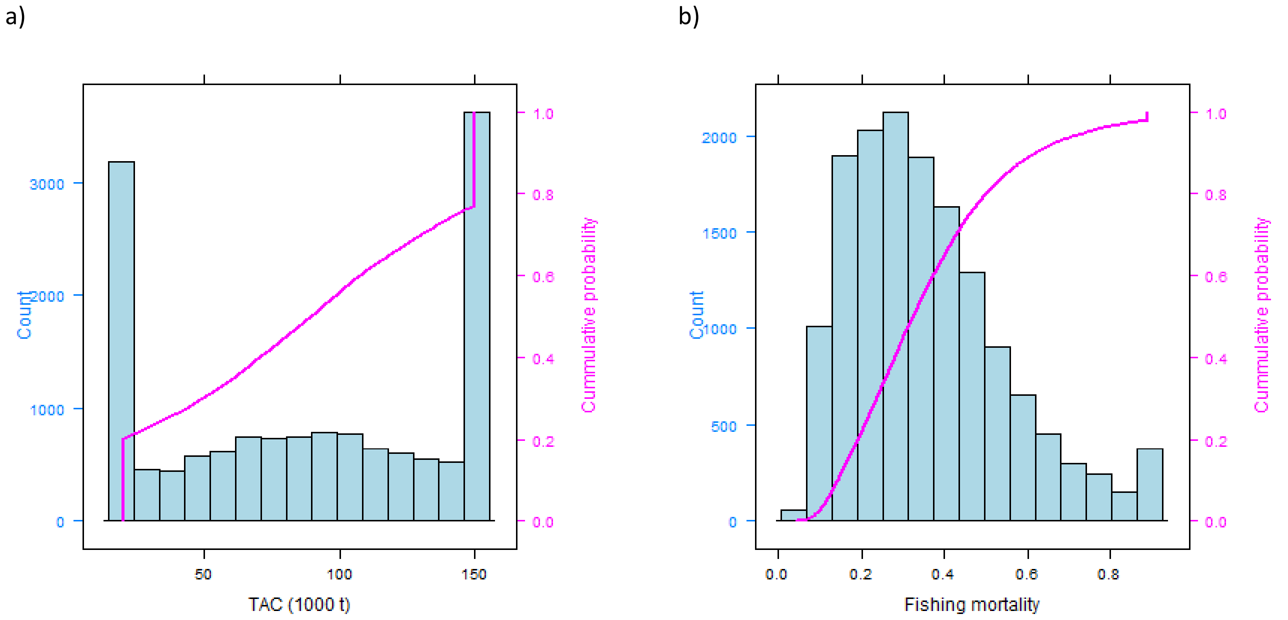

Figure 2 Long-term distribution of a) TAC and b) mean F for the HCR in the request part 2, with TAC_{min} at 20 000 tonnes, TAC_{max} at 150 000 tonnes, and F_{cap} at 0.3.

Request part 3

Due to time limitation and limited input from stakeholders on possible HCRs, ICES was not able to fully cover this part of the request. Request parts 1 and 2 provide HCR scenarios that include a TAC_{min} of up to 30 000 tonnes. As an example of an HCR with a TAC_{min} of 40 000 tonnes, the escapement SSB (the minimum SSB left after the TAC has been taken) was increased from B_{lim} (39 450 tonnes) to 65 000 tonnes. Three scenarios were found to be precautionary (Table 3) for HCRs with combinations of F_{cap} in the range of 0.3 to 0.4 and TAC_{max} in the range of 150 000 to 200 000 tonnes. The TAC is set at TAC_{min} in about 48% of the cases, which gives a median TAC slightly above TAC_{min}. The mean TAC for the three HCR scenarios is in the same order of size as for the request part 2.

Table 3 Long-term summary statistics for precautionary HCR scenarios for the request part 3, applying TAC_{min}, TAC_{max}, and F_{cap} and with a $B_{escapement}$ at 65 000 tonnes.

Scenario*	F_{cap}	TAC_{min} (tonnes)	TAC_{max} (tonnes)	Long-term P(SSB< B_{lim}) (%)	TAC median (tonnes)	TAC mean (tonnes)	TAC change (tonnes)	At $F_{historical}$ (%)	At TAC_{min} (%)	At TAC_{max} (%)
28	0.3	40000	150000	4.87	47753	75843	34013	2.1	47.9	14.4
29	0.3	40000	200000	4.89	46278	80323	41546	2.4	48.3	6.6
31	0.4	40000	150000	4.95	46387	80923	37221	3.0	48.4	22.4

* See Table 4.

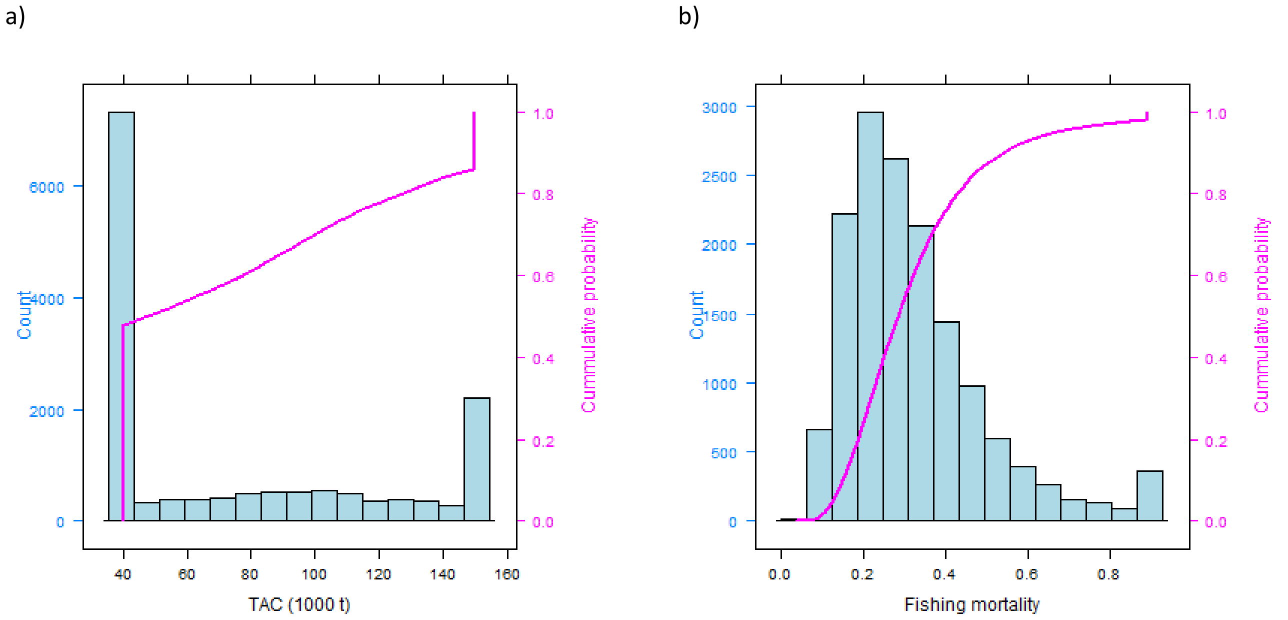

Figure 3 Long-term distribution of a) TAC and b) mean for the HCR in the request part 3, with TAC_{min} at 40 000 tonnes, TAC_{max} at 150 000 tonnes, and F_{cap} at 0.3, and with a $B_{escapement}$ at 65 000 tonnes.

Effect of changes in TAC year on the evaluation results

ICES is asked to evaluate whether the results of the evaluation would be significantly changed if the TAC year were defined as 1 November to 31 October rather than a calendar year. The 1 November to 31 October TAC year is applied by the EU Member States fishing in EU waters, while Norway uses the calendar year (January–December). ICES advice is based on a forecast for the period 1 October to 30 September, and ICES uses such a forecast to provide catch scenarios for the period 1 November–31 October. The evaluation adopted to answer the request follows the same practice. ICES has not compared the results of the evaluation for the TAC year defined as 1 November to 31 October with those for a calendar year, as the latter would require a time shift in the benchmarked assessment and forecast used at present.

The present timing of assessment and TAC period was chosen because it allows the use of recruitment indices from the quarter 3 surveys and because the total catches in quarter 3 are usually low, minimizing the uncertainties associated with the total catch assumptions in quarter 3 of the terminal year. A shift in TAC year to follow the calendar year would provide a more uncertain TAC as the catches in quarter 4 would then be set without knowledge of the strength of the incoming year classes. Around 50% of the annual catches were taken in quarter 4 in the period 2013–2016, which shows that the application of the suggested HCR with a different TAC year may provide a result very different from the one obtained with the current TAC year.

The advice is based on projections from 1 October to 30 September; this means that there will be a mismatch between the TAC assigned to this period and the catch made in the TAC period 1 November to 31 October, because part of the catch in the forecast period for the advice is always taken at the expense of the previous TAC. The significant percentage of catches in quarter 4 indicates that this is a problem which needs further investigation, if the present management system continues. The WKNPOUT report (ICES, 2018) includes further considerations on the current practice for advice and the TAC year.

Suggestions

ICES evaluated the current procedure for providing TAC advice for Norway pout, based on an escapement strategy. Results showed that such an approach is not precautionary as the current method does not include any constraint in F when setting the TAC. The use of an F_{cap} at 0.70 would make the escapement strategy precautionary. With just an upper limit on the F that the fishery can exert ($F_{historical}$ = 0.89, as used for the other evaluations), but no F_{cap}, the probability of SSB falling below B_{lim} decreases to less than 5%. However, with this approach the probability of reaching $F_{historical}$ was 35.9%, which ICES considers to be too high. If there is no agreed management plan, the method for giving TAC advice for ICES should therefore be the escapement strategy, with an additional F_{cap} at 0.70. See Annex 4 of the WKNPOUT report (ICES, 2018) for further details.

Basis of the advice

Background

The aim of the request is an evaluation of the possibilities of having a sustainable fishery for Norway pout with a minimum TAC (e.g. 20 000 tonnes or other values) each year at the cost of long-term maximum yield, either by constraining the maximum levels of TAC (setting a TAC_{max}) or the fishing mortality (setting an F_{cap}), or both. ICES did a similar evaluation in 2012 (ICES, 2012) and advised at the time that the minimum TAC should not exceed 20 000 tonnes. A main constraint required in the former evaluation was that for any of the options to be precautionary, future fishing mortality should not significantly exceed the range of values observed in the last decade (0.6).

Results and conclusions

ICES performed stochastic simulations for a wide range of combinations of TAC_{min}, TAC_{max}, and F_{cap} to test whether the different harvest control rules (HCRs) result in no more than a 5% probability of the SSB falling below B_{lim} in the period 2023–2037. Such HCRs are by definition considered precautionary by ICES. Due to the presently high stock size, HCRs that were precautionary in the long term were also precautionary in the period 2018–2022.

The performance statistics from all the evaluated HCRs are presented in Table 4. The results of the simulations should be used for comparison between scenarios and not as forecasts of absolute quantities.

Table 4 Summary statistics for HCRs for the request parts 1, 2, and 3, and an escapement strategy with F_{cap} = 0.7. Two runs of sensitivity analysis to the stock–recruitment relationship (using the Eqsim function), carried out on two concrete HCRs, are shown at the bottom of the table. Shaded HCRs have more than 5% probability of SSB being below B_{lim} in the long term and are not considered precautionary.

Scenario		F_{cap} (per year)	TAC_{min} (tonnes)	TAC_{max} (tonnes)	SSB (tonnes)	P(SSB< B_{lim}) short term (%)	P(SSB< B_{lim}) long term (%)	F_{bar} (per year)	At $F_{historical}$ (%)	TAC median (tonnes)	TAC mean (tonnes)	TAC change (tonnes)	At TAC_{min} (%)	At TAC_{max} %
	Default escapement with F_{cap}	0.70	0	500000	103282	4.8	4.87	0.493	0.2	109479	138244	123917	0	0
1	Request part 1	2	0	150000	118036	2.2	2.27	0.359	9.2	132170	96908	49911	0	46.5
2		2	0	200000	111597	2.3	2.39	0.423	16.7	125961	115542	69988	0	36.9
3		2	20000	150000	116075	3.1	3.74	0.367	9.1	130054	99597	44950	20.8	46
4		2	20000	200000	109826	3.2	3.94	0.429	16.4	123299	118119	64608	21.7	36.4
5		2	30000	150000	114750	3.6	4.86	0.391	9.6	128023	101179	41826	24.6	45.7
6		2	30000	200000	108491	3.9	5.09	0.452	16.9	122024	119789	61308	25.4	36.2
7		2	40000	150000	113070	5.1	6.19	0.423	11.1	126556	103419	38496	28.2	45.3
8		2	40000	200000	106990	5.2	6.44	0.485	18.2	120333	121895	57656	29.2	35.9
9	Request part 2	0.3	0	150000	132136	1.8	1.69	0.269	0.6	72704	74854	44064	0	14.5
10		0.4	0	150000	125320	2	2.01	0.317	2.2	90675	85092	47811	0	23.6
11		0.3	0	200000	130885	1.8	1.69	0.28	0.8	72391	79345	51730	0	6.7
12		0.4	0	200000	122764	2	2.05	0.342	3.1	89399	92791	59751	0	12.5
13		0.3	20000	150000	130447	2.6	3.17	0.278	0.7	72265	77453	39497	19.1	14.3
14		0.4	20000	150000	123637	3	3.55	0.325	2.2	89742	87686	42865	20.1	23.4
15		0.3	20000	200000	129123	2.6	3.19	0.289	0.9	71968	81944	47072	19.2	6.7
16		0.4	20000	200000	120708	3	3.61	0.348	3.1	88465	95345	54578	20.4	12.4
17		0.3	30000	100000	133303	3.2	3.99	0.27	0.8	72941	69002	23265	22.6	32.9
18		0.4	30000	100000	129159	3.2	4.29	0.294	1.4	91547	74100	22868	22.9	45.8
19		2	30000	100000	126733	3.4	4.42	0.305	3.2	100000	77313	22140	23.1	59.3
20		0.3	30000	150000	128784	3.3	4.14	0.298	1.1	71706	79107	36744	22.9	14.2
21		0.4	30000	150000	122030	3.4	4.55	0.346	2.7	89236	89391	40005	23.8	23.2
22		0.3	30000	200000	127501	3.3	4.17	0.307	1.4	71367	83574	44260	23.1	6.6
23		0.4	30000	200000	119407	3.4	4.67	0.369	3.6	88057	97107	51715	24.2	12.3

Scenario		F_{cap} (per year)	TAC_{min} (tonnes)	TAC_{max} (tonnes)	SSB (tonnes)	P(SSB< B_{lim}) short term (%)	P(SSB< B_{lim}) long term (%)	F_{bar} (per year)	At $F_{historical}$ (%)	TAC median (tonnes)	TAC mean (tonnes)	TAC change (tonnes)	At TAC_{min} (%)	At TAC_{max} %
24		0.3	40000	150000	127046	4.2	5.27	0.318	2.4	71361	81325	33638	28.1	14.1
25		0.4	40000	150000	120278	4.6	5.74	0.372	4.1	88230	91539	36872	27.6	23
26		0.3	40000	200000	125938	4.2	5.28	0.328	2.6	71029	85743	41063	28.4	6.6
27		0.4	40000	200000	117590	4.6	5.85	0.395	5	87130	99189	48369	28	12.2
28	Request part 3	0.3	40000	150000	132145	3.6	4.87	0.286	2.1	47753	75843	34013	47.9	14.4
29		0.3	40000	200000	130727	3.6	4.89	0.296	2.4	46278	80323	41546	48.3	6.6
30		0.4	40000	150000	129132	3.7	4.95	0.303	3	46387	80923	37221	48.4	22.4
31		0.4	40000	200000	126216	3.9	5.02	0.321	3.9	44197	88537	48775	49.1	12.5
	Sensitivity to S–R	0.3	20000	150000	127564	2.3	3.27	0.279	0.7	70236	76408	38972	18.7	13.7
	Sensitivity to S–R	0.4	30000	200000	114767	3.6	5.9	0.279	4.2	83326	93837	49854	25.6	11.2

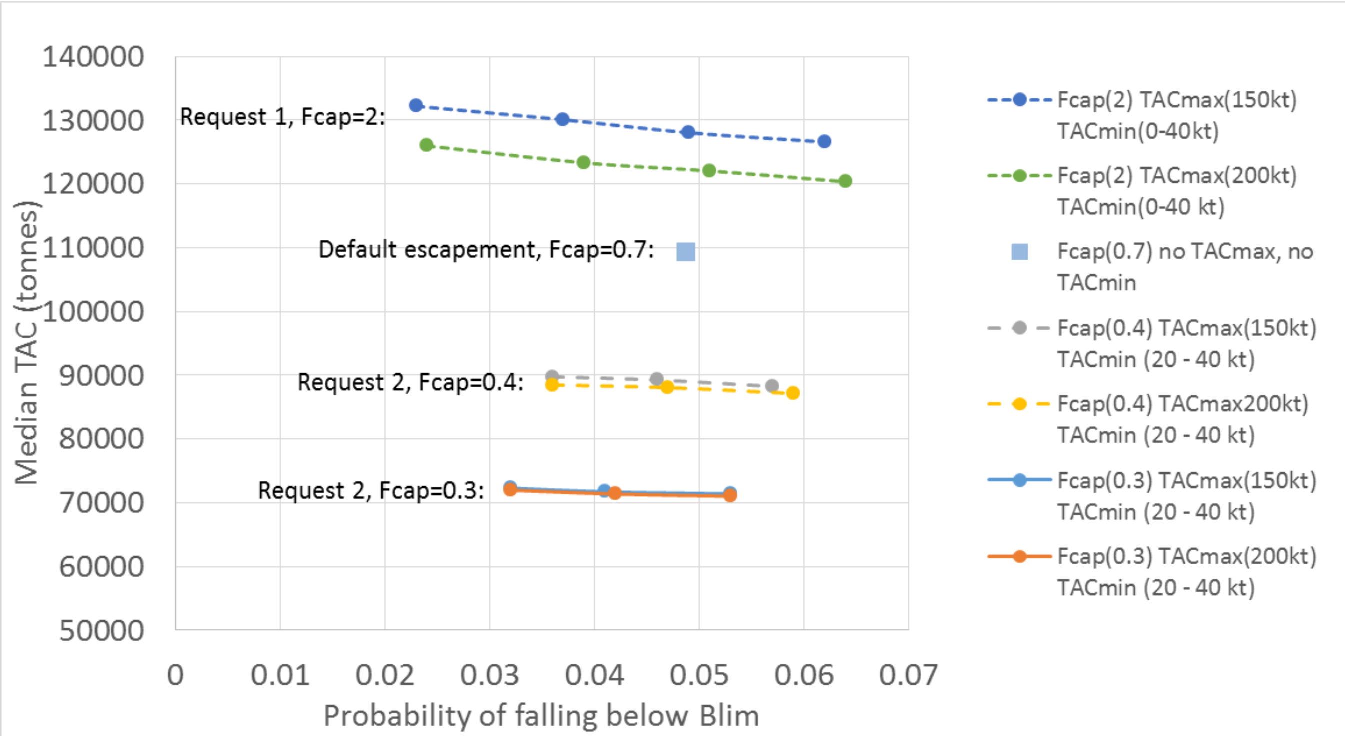

Figure 4 TAC (median TAC) versus the probability of SSB falling below B_{lim} for different levels of F_{cap} (0.3, 0.4, and 2) and levels of TAC_{max} (150 000 or 200 000 tonnes). Dots in lines from left to right refer to the increasing levels of TAC_{min} (either from 0 to 40 000 tonnes for the F_{cap}(2) level or from 20 000 to 40 000 tonnes for the other F_{cap} values). The point for the default escapement strategy with neither TAC_{max} nor TAC_{min}, but bounded by an F_{cap} = 0.7, is also shown for comparison.

Figure 4 shows the median TAC and the probability of SSB falling below B_{lim} in the HCRs evaluated. TACs for HCRs with TAC_{min} and TAC_{max} bounds are mainly determined by the F_{cap} value, where the lowest F_{cap} level gives the lowest median TAC. The value of TAC_{min} itself has only a limited effect on the median TAC, but determines the probability of SSB being below B_{lim} and thereby whether the HCR is precautionary. TAC_{max}, in the range of 150 000–200 000 tonnes has only a limited effect on the median TAC. The default escapement strategy, with no TAC_{min} or TAC_{max}, but with an F_{cap} at 0.70 (highest F_{cap} within precautionary limits) has a lower median TAC than the HCR in part 1 of the request. The highest mean TAC is, however, obtained by the default escapement strategy (Table 4).

Realism in the simulation regarding realized fishing mortality

Escapement strategies used for short-lived species, where the catch opportunities are very dependent on the strength of the incoming year class, may result in the TAC being set too high due to uncertainties in the estimate of the incoming year class. The evaluations were conditioned by the maximum realized level of fishing mortality the fishery can exert (assumed at 0.89; $F_{historical}$), which means that the full TAC will not be taken if the required F exceeds this value. The probability of SSB falling below B_{lim} is sensitive to the value of $F_{historical}$, especially for HCRs without an F_{cap}. The $F_{historical}$ at 0.89 used in the evaluation is the 97.5th percentile of the highest estimate of F in the last 20 years (F in 2013 estimated by the 2017 assessment). Whether this value is the most appropriate one is impossible to judge; however, the following observations support an $F_{historical}$ that is not very high.

- Norway pout is a demersal species, where CPUE is expected to decline with declining stock size. Given the low price (landed for production of fishmeal and oil), the profitability of the fishery is expected to become too low to continue fishing at very low stock size.

- The stock area is wide and only part of the stock area is fished. "The Norway pout box", which is an area closed for the Norway pout fishery, will also provide some protection against a potential high F.
- The number of vessels and overall fishing capacity has been decreasing and the remaining fleets have often better (more profitable) alternatives than fishing for Norway pout, so that overall fishing effort on Norway pout has also decreased. A lower fishing effort for Norway pout is supported by the low F and underutilization of the quota in recent years.

Figure 5 shows the distribution of historical and simulated catch weight, F_{bar}, recruitment, and SSB, from one of the HCRs applied (F_{cap} = 0.3, TAC_{min} = 30 000 tonnes, and TAC_{max} = 150 000 tonnes). The panels for F_{bar} and catch weight show an immediate increase from the first simulation TAC year (2018). This is because the TAC in most of the recent years has not been taken, while it is assumed in the simulations that the TACs will be caught. In the case of future lower TAC uptake, the probability of reaching TAC_{min} will be lower than that shown for the individual HCRs.

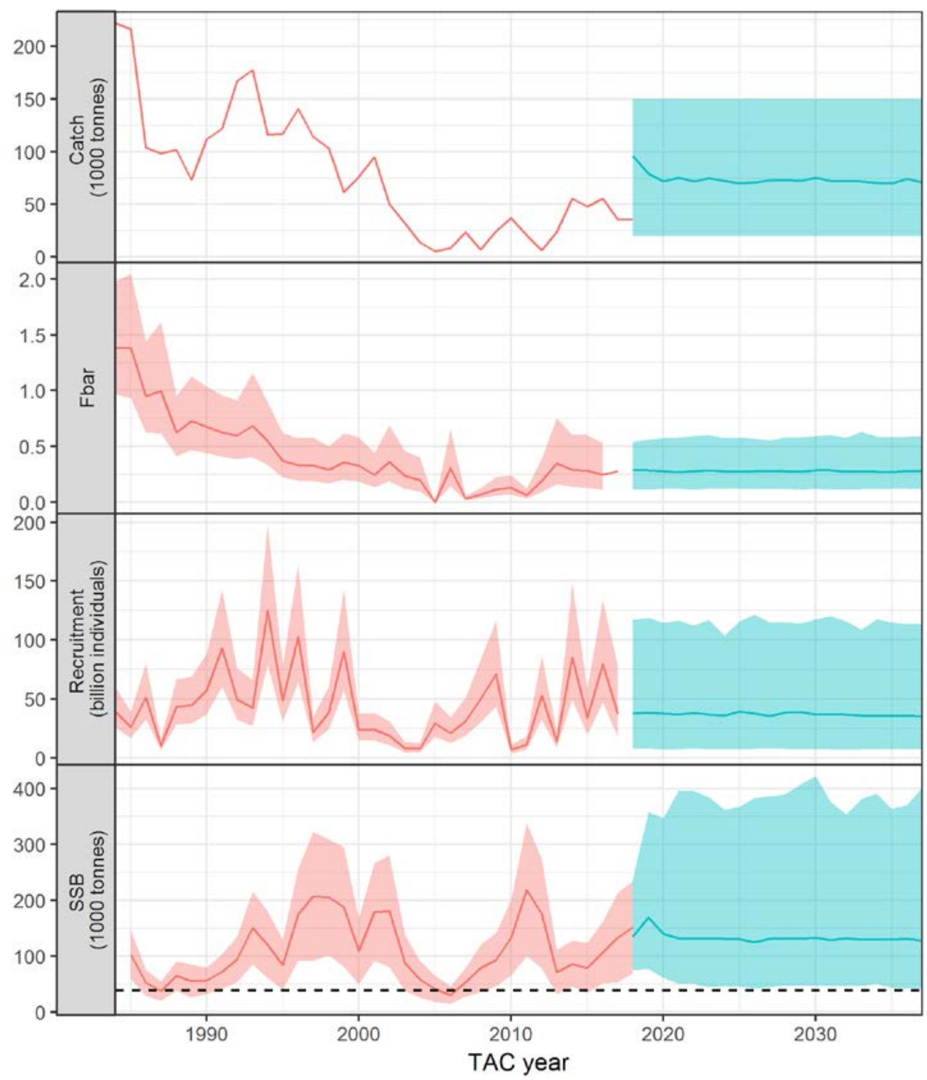

Figure 5 Summary result from the SESAM assessment of Norway pout (in red) and scenario values using an example HCR (in blue – F_{cap} = 0.3, TAC_{min} = 30 000 tonnes, and TAC_{max} = 150 000 tonnes). The lines show the median value and the shaded areas the 5th and 95th percentiles.

Methods

A management strategy evaluation (MSE) methodology was applied for the evaluation of harvest control rules. The evaluation methodology followed ICES guidelines for management strategy evaluation (ICES, 2013).

The results from the latest stock assessment, conducted in 2017 (ICES, 2017a) using the SESAM model, formed the basis for parametrizing the underlying population dynamics model and fishery specifications (operating model, OM). Natural mortality, mean weight-at-age in the stock, and proportion mature were the same as the fixed input used by SESAM. Starting stock numbers (N), exploitation pattern (E), and past recruitment were estimated by SESAM, drawn randomly from the joint distribution of each of the thousand simulation iterations. The OM matched the Norway pout stochastic forecast in terms of processes and input parameters. Given N(a,t), the number of fish of age a in quarter t, mortality, and process error are implemented as $N(a,t+1) = N(a,t) \times \exp(-(F(a,t) + M(a)) + epsilon(a,t))$, where epsilon(a,t) is drawn from a normal distribution with a mean of 0 and standard deviation at 0.19, as in SESAM.

The SESAM model operates by quarterly time steps. Recruitment occurs in quarter 3 based on the SSB in quarter 1; it is a random sample from past recruitment if SSB > B_{lim} (i.e. nonparametric bootstrapping), or a hockey-stick analysis with truncated log-normal error if SSB < B_{lim}. The probability of SSB being below B_{lim} is evaluated at the beginning of quarter 4, as done in ICES assessment. Additionally, since SSB in quarter 1 determines recruitment, the risk was calculated of this SSB dropping below the break in the assumed hockey-stick model (at 72 101 tonnes = B_{loss} in quarter 1 of 2005). The evaluations show consistency between the probability of the biomass being below B_{lim} in quarter 4, and the probability of it falling below the minimum historical biomass at the spawning time in quarter 1.

For each HCR, the evaluation used 1000 independent iterations, each running forward for 20 years. The SESAM model was not included within the simulation loop of the evaluation. Instead the state of the OM was estimated by an assessment emulator (AE). To get an estimated state of the system the AE drew at random, in each year of the evaluation, an estimated state (log N and log E) from a multivariate normal distribution, which has the true state as the mean and a variance–covariance matrix as estimated by SESAM.

The implementation model assumed the fleet has a maximum achievable F_{bar} of 0.89 ($F_{historical}$), based on past estimates. That means that the TAC in some years may not be taken.

A decision was made to use an ICES type 1 risk definition for the long term (average probability over the years 2023–2037 of the spawning biomass being below B_{lim} [Prob 1]), rather than the type 3 definition (maximum probability that SSB-Q4 is below B_{lim} [Prob 3]) recommended by ICES (ICES, 2013). The results show that risk type 3.long.Q4 > Risk type 1.long.Q4. However, in the stationary situation, Prob 3 = Prob 1 and therefore only Prob 1 should be computed (ICES, 2013). In summary, Risk 3 is taken as the reference for the short term, while Risk 1 is taken for the long term as the best estimation of Prob 3.

A sensitivity test found that if the OM instead simulates recruitment with the Buckland method (Millar *et al.*, 2017), applying an estimated 53-38-9% split of the weights on the hockey-stick analysis (Ricker and Beverton–Holt, respectively), then the probability of SSB falling below B_{lim} increases by about 1% (see Table 4). Another sensitivity test showed that taking the best estimates of exploitation pattern, past recruitment, and initial population numbers without uncertainty led to a reduction in the probability of SSB being below B_{lim} by about 2–3%.

A full description of the method and extensive output from each HCR can be found in the WKNPOUT report (ICES, 2018).

Additional information

The probability of SSB falling below B_{lim} for each HCR is very sensitive to the actual value of B_{lim}. At the last benchmark (ICES, 2017a), B_{lim} was set to B_{loss}, the lowest observed biomass (in 2005) because no clear stock–recruitment relationship was identified. ICES has not updated the reference points for Norway pout, as the addition of the most recent stock–recruitment points did not change the perception of the stock–recruitment relationship. Given the sensitivity of the results to the selection of B_{lim}, any future emergence of a clear stock–recruitment relationship will require a re-evaluation of the stock.

Sources and references

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