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ICES ADVISORY COMMITTEE

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Evaluation of proposed long term management plan for Celtic Sea herring

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1 Introduction

In 2008, the Irish local fishery management committee developed a rebuilding plan for this stock. In 2009, the plan was evaluated by ICES and found to be in accordance with the precautionary approach, within the estimated stock dynamics. The plan was adopted by the Pelagic RAC and it was used as a basis for the 2010 and 2011 TACs. The plan came to completion at the end of 2011, with full rebuilding, however the HCR within it was used as the basis for setting the TAC in 2012.

A long term management plan to supersede this rebuilding plan has been proposed by the Irish industry, the local committee and the Pelagic RAC. This plan has been forwarded to ICES by Ireland, to evaluate if it is in accordance with the Precautionary Approach and MSY. The plan and request is presented above, and a schematic representation of the harvest control rule is presented in Figure 1. Below, are the results of simulations conducted to evaluate the precautionary nature of this plan, and its accordance with MSY.

2 Materials and methods

Simulations were carried out using HCS_10_3 which is a general purpose program for stochastic simulation of management decision rules (Skagen, 2010 a). This program allows screening over ranges of options for the harvest rule design, the assessment-prediction-decision process and incorporation of various errors and biases. The program consists of a population model that generates yearly true stock numbers at age, an observation (assessment) model that transfers the stock numbers into “noisy”, observed numbers, a decision rule through which a TAC is derived according to the observed stock (projected forward if relevant) and an implementation model that translates the TAC into actual removals. These removals are then inputted to the population model for the next time step. This software has already been used to evaluate the long term plan for blue whiting, the rebuilding plan for Celtic Sea herring and was one of the methods used in the long term management simulations for NEA mackerel. Simulation replicates were performed 1 000 times.

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The latest assessment (2012) was used as a basis for the simulations, and 2012 as was used as the starting year of 20. The settings used are as per the benchmark assessment (Table 1). Settings in the assessment were otherwise as per the base case evaluation above. The estimate of catch in the intermediate year was taken as the 2012 Irish quota which is 18 236 t, as per the short term forecast used by ICES in 2012.

The stock recruit model chosen was the segmented regression, and was fitted using Julio's algorithm (Julio, 2001) to the data from 1958-2009. Data from the most recent two years were excluded because they are less well estimated. Model fitting was conducted using R. The SSB changepoint was estimated at 39,000 t, and the plateau level of recruitment at 415 million individuals (Figure 2), see text table below.

Slope	Plateau Recruitment	SSB Changepoint	SSQ	P	S.E
10.63	415 940 million	39 143 t	17.72	0.03	0.6

A log-normal distribution of the recruitments was assumed. The distribution was truncated (0.1 and 3.0) to avoid drawing recruitments far outside the historical range. The modelled and expected distributions of recruitments are shown in Figure 2. Cumulative probabilities in the range 0.1 to 0.4 the model predicts higher recruitment than observed. At higher probabilities the model tends to underestimate recruitment very slightly.

In order to examine various uncertainties, and stress test the proposed rule, a number of scenarios were examined, screening over a range of errors and biases. This was first done individually for each type of error and bias, and then combinations of these were considered. Finally the most plausible combinations were used to stress test the HCR. The choice of these was based on evaluations of the data available and prevailing conditions in the fishery. Additional stress testing examined the effect of changes to these conditions, and a sustained period of low recruitment such as observed in the 1970s.

CV on the observation model was set at 0.24, based on bootstrapped re-sampling of SSB estimates from the final 2012 assessment (Figure 3). Implementation bias was screened over the range -0.3 to +0.3, covering a range of +/- 30% undershoot or overshoot of the TAC. Implementation error was screened over the range 0.1 to 0.3, with 0.1. Assessment bias was screened over the range -0.53 to + 0.16, the absolute range observed from historical retrospectives since the stock was last benchmarked (Table 2). Before this time, no final assessment was available.

In order to examine the effect of a series of low recruitments, an additional simulation was performed. This made use of functionality in HCS where trends in recruitment can be modelled with a cosine wave function. The amplitude of this function was 0.888, the periodicity was 24, with a phase of 3.034. This represents a 24 year gap between peak observed recruitments (1965 and 1989), whilst modelling well the long string of low recruitments in the 1970s (Figure 4). It is not clear whether the low recruitment in the 1970s was a feature of an industrial fishery at that time, or due to some underlying cycle. However this model fits the low phase quite well, though not so well subsequent observations, and overall r^2 was very poor.

Finally including autocorrelation on the observation model was also tested, screening over a range of coefficients from -0.8 to +0.8. There was little evidence that autocorrelation is a feature of the data, especially in recent years, and hence was not included in the further analyses.

Further simulations were conducted combining the various errors and biases to produce the most plausible set. Implementation error was set at 0.0, there being no basis to assume otherwise. Implementation bias set at +0.1, representing a 10% TAC overshoot. This is considered to represent the maximum observed discarding rate observed in the fishery (Irish Whale and Dolphin Group, Unpublished Data), and may be a considerable overestimate. It is not thought that extra-quota fishing is a feature

of the fishery at present, so no additional bias was added. The TAC is usually under-shot each year, due to a less than efficient weekly allocation system within Ireland. It can be seen from Table 3, that the advised and implemented TACs have been mainly undershot in recent years. The effect of the undershoot means that assuming a 10% positive bias may be a considerable overestimate. However it can be considered a precautionary assumption. Assessment error was set at 0.24, taken from the final assessment in 2012, and assessment bias was set at +0.03, based on the average historic retrospective bias in recent (non-converged VPA) assessments (Table 3). Autocorrelation was not considered in this case.

The text table below shows these assumptions, and also an upper bound on each, that provided for a stress test.

Parameter	final	stress test of final
Observation bias	1.03	1.1
Observation error	0.24	0.34
Implementation error	0.0	0.1
Implementation bias	0.1 (-0.07*)	0.2

*As noted above, the final implementation bias was set at +10%, which may be an overestimate. By way of contrast a run was conducted with slight negative bias (-7%).

The risk was evaluated for SSB reaching B_{lim} (26 000 t) and. B_{lim} is considered appropriate, based on ICES guidelines (ICES SGPA 2003). B_{loss} is considered a good candidate for B_{lim} when there is no obvious decline in observed recruitments, and where a range of recruitments are observed at the lowest SSB. Risk of reaching the stock-recruit change point (39 000 t) was also evaluated.

In order to evaluate the effect of the TAC constraint in the HCR, the final runs were repeated without the TAC constraint being applied

3 Results

Risk was taken as the number of trajectories in percent terms at least once in the time period. In order to conform to ICES procedures, if risk of being below the SSB change point in any given year was greater than 5%, the scenario was considered not to be in conformity with the precautionary approach. Given that TAC constraint is a key feature of the plan, it is clear that the plan does not provide for maximum sustainable yield. However it can be concluded that the plan achieves stable yield over time, at the expense of maximising yield in any one year.

With the assessment error is 0.24 as per the latest assessment, the risk (to B_{lim} or $B_{change\ point}$) was less than 5%. When the CV was increased to 0.34 and 0.44 the risk was greater than 5% in the majority of years. The latter range of CVs is beyond the range observed in assessments. A range of assessment biases was not associated with unacceptable risk in the range -3%, 8%. The extreme observed negative bias, -35% had unacceptable risk in the first 8 years only. At the other extreme, a bias of + 53% the risk of being below the breakpoint was above 50%. The extreme biases were observed on single occasions, and the mean bias was estimated as being +0.3 from all benchmark assessments. Examination of implementation error found risk between 5 and 6% in a small number of years, at values of 0.3, but risk was at acceptable levels at values of <0.2. Results of these simulations are contained in Annex 1, with risk reported for $B_{change\ point}$.

Examining the effect of a long period of low recruitment, by means of a wave function, found that risk reached elevated levels by 2024, or 2027 if other errors and biases are ignored. However it is not clear if the wave function explains the underlying cycle in recruitment, or whether the low phase in the 1970s was due to other factors, such as the industrial fishery. Technical measures such as minimum size and closed areas mean that this industrial fishery is very unlikely to occur again.

The most plausible set of errors and biases tested were not associated with risk in any year of greater than 5% of stock collapse (Annex 2). Implementation errors of greater than 0.1 have marginally elevated risk, but values less than 0.1 have acceptable risk profiles. Implementation bias in the range ± 0.07 was associated with acceptable risk, but a bias of $+0.1$ was associated with marginally elevated risk in a number of years. There was little evidence that autocorrelation is a feature of the data, especially in recent years, and hence was not included in the final analysis. However stress testing of the HCR against a broad range of coefficients is provided in Annex 2, with only a high negative autocorrelation showing marginally elevated risk (reported for $B_{\text{change point}}$).

Final runs were conducted that used the most plausible range of errors and biases, and these are presented in Annex 3. The final runs summary results are shown in Tables 4-8. The most plausible settings show low risk ($< 5\%$) to either biomass level, but the stress testing displays higher than 5% risk. These risk profiles do not alter if the TAC constraint is removed. Table 6 shows that stress testing of the HCR with more extreme errors and biases is associated with risk greater than 5%. The contrast final run (with slight negative implementation bias) which is thought to be a better representation of fisheries conditions, shows acceptable levels of risk to both biomass levels (Table 7), and higher realised TACs than the final scenario.

Changes to the HCR

Though the HCR performs well in terms of precaution, it does not deliver MSY. This is due to the TAC constraint. Stakeholders (in Pelagic RAC) are happy with the TAC constraint, as it gives them stability in catch. However we provide simulations of the HCR without the TAC constraint for illustrative purposes. The highest target F associated with acceptable risk is 0.27, at the proposed biomass trigger. It is clear that a target F of 0.27 is possible, when the TAC constraint is not used. It should be noted that this is conditional on the trigger biomass used, and even higher target F (up to 0.3 cited in ICES HAWG 2010) might be possible at different trigger biomasses.

The effect of different choices of biomass trigger, % TAC constraint and target F are further illustrated in Figures 5-7, for risk, realised and SSB. The effect of reducing the trigger biomass is further considered in a series of runs presented in Annex 4. These runs tested the existing HCR using the final run settings, but considering a range of triggers from 41 000 t to 61 000 t. The summary results of these are shown in Table 9. In contrast to the final runs, the realised SSB remains above the trigger, when the trigger is reduced. If bias in implementation is in the range of 10% as per the final run, then the HCR may be triggered to deliver lower F than the target. However if bias is overestimated then the proposed trigger will not be breached, on average.

Closed area evaluation

Mean F from the latest assessment was examined in the context of whether Division VIIaS was closed or not. Mean F for periods of closure, and partial closures were compared (Table 9). The closure was associated with considerable reductions in F and a preliminary conclusion is that Clause 5 is an appropriate additional measure to assist rebuilding, by reducing F . The partial F associated with the sentinel fishery provision in Clause 6 is unlikely to be significant, given that overall F would be very low due to the provisions of the HCR. The closed area is shown in its geographic context in Figure 8.

ICES is not in a position to simulate the effect of the closed area. But from an operational point of view it seems to have worked to reduce in the past.

4 Discussion

The proposed harvest control rule is in accordance with the precautionary approach though it delivers yields that are lower than maximum sustainable levels. This is not a criticism of the plan however, because it delivers stability in TAC over time at the expense of maximising yield in any individual year. Stakeholders, as represented within the Pelagic RAC are have made the conscious choice of having stable rather than maximum yield over time.

The proposed plan performs well, with low risk to low biomass within the most likely conditions pertaining in the fishery system. This was evaluated over a range of errors and biases. However the plan fails to deliver low risk if error and bias is more extreme than modelled. The issue of discards is worth considering in this regard. Assuming that maximum discarding is less than 10% in addition to reported catch, the plan still behaves within the PA approach. But if discarding is beyond that range, the plan begins to fail. Latest information from independent discard monitoring by the Irish Whale and Dolphin Group shows suggests that our assumptions are valid. This information also suggests that the maximum discard rates considered by ICES HAWG 2012 are considerable overestimates.

The effect of additional catch due to discarding may be compensated by TAC undershoot and this was also evaluated. It appears that the effect of TAC undershoot reduces likely implementation somewhat.

These simulations considered risk to B_{lim} (26 000 t) and also the changepoint in the S/R relationship. The former SSB value as considered more appropriate as a reference for risk evaluation by the external reviewers within RG/ADGCSHER, and have taken precedence here. It is noted that HAWG in the past has proposed increasing B_{lim} to the S/R changepoint with consequent increased in B_{pa} . This may not be necessary, based on ICES SGPA 2003 guidelines. It should also be noted that the changepoint in the segmented regression has been quite volatile over time (39 000 – 45 000 t) in various studies conducted in recent years. This volatility is considered a good reason not to use changepoint as a basis for B_{lim} .

We are aware that the local Irish committee has a long term objective of annual catch of 20 000 t annually. This is higher than the estimated average TACs delivered by the proposed HCR. This anomaly has caused concern for stakeholders several times. Further work should be conducted in the benchmark (planned for 2014) to examine if the industry perception of stable catch is indeed justified. This may be due to underestimates of natural mortality or fishing mortality in the historic period, and further work will be conducted on this.

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Table 1. Input data used in the simulations, based on assessment in 2012, and following the benchmark (2009).

Age	Stock weights (kg) (3- year average)	Catch Weight (kg)	Population numbers Forecast	Proportion Mature Time invariant	Selection Assessment	Natural mortality Time invariant
1	0.073	0.074	440602	0.5	0.0082	1
2	0.11	0.111	160548	1	0.0695	0.3
3	0.132	0.134	183174	1	0.1483	0.2
4	0.145	0.148	169050	1	0.1531	0.1
5	0.156	0.159	34811	1	0.1483	0.1
6	0.168	0.171	120265	1	0.1483	0.1

Table 2. Traffic light table of historical retrospective bias in recent assessments. Red indicates retrospective over-estimation of more than 10%, green indicates underestimation of less than 90% and amber the range in between. At the bottom are indicated mean retrospective bias over various year ranges.

SSB	2012/2011	2011/2010	2010/2009	2012/2010	2011/2009	2012/2009	2010/2012	2010/2011	2009/2012	2009/2011	2009/2010	2011/2012
1958	0.89	0.98	1.04	0.90	1.01	0.90	1.16	1.02	1.11	0.99	0.96	1.13
1959	0.89	0.98	1.03	0.90	1.01	0.90	1.14	1.02	1.11	0.99	0.97	1.12
1960	0.92	0.98	1.03	0.93	1.01	0.93	1.11	1.02	1.08	0.99	0.97	1.09
1961	0.91	0.98	1.03	0.92	1.01	0.92	1.12	1.02	1.09	0.99	0.97	1.10
1962	0.91	0.98	1.03	0.92	1.01	0.92	1.12	1.02	1.09	0.99	0.97	1.10
1963	0.89	0.98	1.03	0.90	1.01	0.90	1.14	1.02	1.11	0.99	0.97	1.12
1964	0.91	0.98	1.03	0.92	1.01	0.92	1.12	1.02	1.09	0.99	0.97	1.10
1965	0.90	0.98	1.03	0.91	1.01	0.91	1.13	1.02	1.10	0.99	0.97	1.11
1966	0.92	0.98	1.03	0.93	1.01	0.93	1.11	1.02	1.08	0.99	0.98	1.09
1967	0.93	0.99	1.02	0.94	1.01	0.94	1.09	1.01	1.07	0.99	0.98	1.08
1968	0.94	0.99	1.02	0.95	1.01	0.95	1.07	1.01	1.06	0.99	0.98	1.06
1969	0.95	0.99	1.01	0.96	1.00	0.96	1.06	1.01	1.05	1.00	0.99	1.05
1970	0.95	0.99	1.02	0.95	1.01	0.95	1.07	1.01	1.05	0.99	0.98	1.06
1971	0.96	0.99	1.01	0.96	1.00	0.96	1.05	1.01	1.04	1.00	0.99	1.04
1972	0.97	0.99	1.01	0.97	1.00	0.97	1.04	1.01	1.03	1.00	0.99	1.03
1973	0.97	0.99	1.01	0.97	1.00	0.97	1.04	1.01	1.03	1.00	0.99	1.03
1974	0.97	0.99	1.01	0.97	1.00	0.97	1.04	1.01	1.03	1.00	0.99	1.03
1975	0.96	0.99	1.01	0.96	1.00	0.96	1.05	1.01	1.04	1.00	0.99	1.04
1976	0.96	0.99	1.01	0.96	1.00	0.96	1.05	1.01	1.04	1.00	0.99	1.05
1977	0.97	0.99	1.01	0.97	1.00	0.97	1.04	1.01	1.03	1.00	0.99	1.03
1978	0.97	0.99	1.01	0.97	1.00	0.97	1.04	1.01	1.03	1.00	0.99	1.03
1979	0.97	0.99	1.01	0.98	1.00	0.98	1.03	1.01	1.02	1.00	0.99	1.03
1980	0.97	0.99	1.01	0.98	1.00	0.98	1.03	1.01	1.03	1.00	0.99	1.03
1981	0.98	1.00	1.01	0.98	1.00	0.98	1.03	1.00	1.02	1.00	0.99	1.02
1982	0.98	1.00	1.01	0.98	1.00	0.98	1.03	1.00	1.02	1.00	0.99	1.02
1983	0.98	1.00	1.01	0.98	1.00	0.98	1.03	1.00	1.02	1.00	0.99	1.02
1984	0.97	0.99	1.01	0.98	1.00	0.98	1.03	1.01	1.02	1.00	0.99	1.03
1985	0.97	0.99	1.01	0.97	1.00	0.97	1.04	1.01	1.03	1.00	0.99	1.03
1986	0.97	0.99	1.01	0.97	1.00	0.97	1.04	1.01	1.03	1.00	0.99	1.04
1987	0.96	0.99	1.01	0.96	1.00	0.96	1.05	1.01	1.04	1.00	0.99	1.04
1988	0.96	0.99	1.01	0.96	1.00	0.96	1.05	1.01	1.04	1.00	0.99	1.04
1989	0.96	0.99	1.01	0.96	1.00	0.96	1.05	1.01	1.04	1.00	0.99	1.04
1990	0.96	0.99	1.01	0.96	1.00	0.96	1.05	1.01	1.04	1.00	0.99	1.04
1991	0.96	0.99	1.01	0.96	1.00	0.96	1.06	1.01	1.04	1.00	0.99	1.05
1992	0.96	0.99	1.01	0.96	1.00	0.96	1.06	1.01	1.04	1.00	0.99	1.05
1993	0.96	0.99	1.01	0.96	1.00	0.96	1.06	1.01	1.04	1.00	0.99	1.05
1994	0.96	0.99	1.01	0.96	1.01	0.96	1.06	1.01	1.04	0.99	0.99	1.05
1995	0.96	0.99	1.01	0.96	1.01	0.96	1.05	1.01	1.04	0.99	0.99	1.04
1996	0.96	0.99	1.02	0.96	1.01	0.96	1.05	1.01	1.04	0.99	0.98	1.04
1997	0.97	0.99	1.01	0.97	1.01	0.97	1.04	1.01	1.03	0.99	0.99	1.04
1998	0.96	0.99	1.02	0.97	1.01	0.97	1.05	1.01	1.03	0.99	0.98	1.04
1999	0.96	0.99	1.04	0.98	1.03	0.98	1.05	1.01	1.02	0.97	0.96	1.05
2000	0.95	0.99	1.06	1.00	1.05	1.00	1.06	1.01	1.00	0.95	0.94	1.06
2001	0.91	0.99	1.09	0.99	1.08	0.99	1.10	1.01	1.01	0.92	0.92	1.09
2002	0.89	1.00	1.12	0.99	1.12	0.99	1.13	1.00	1.01	0.89	0.89	1.13
2003	0.84	1.00	1.19	1.00	1.19	1.00	1.19	1.00	1.00	0.84	0.84	1.19
2004	0.78	1.00	1.23	0.96	1.23	0.96	1.28	1.00	1.04	0.82	0.81	1.27
2005	0.72	1.02	1.27	0.94	1.30	0.94	1.36	0.98	1.07	0.77	0.79	1.38
2006	0.70	1.04	1.30	0.95	1.36	0.95	1.37	0.96	1.05	0.74	0.77	1.42
2007	0.68	1.08	1.32	0.96	1.42	0.96	1.37	0.93	1.04	0.70	0.76	1.48
2008	0.65	1.10	1.27	0.92	1.40	0.92	1.38	0.91	1.09	0.71	0.79	1.53
2009	0.65	1.42					1.08	0.71				1.53
2010	0.74											1.36

Mean over various year ranges	
Mean	1.00
mean 10	1.04
mean 5	1.06
mean non converged VPA	1.03
Max all	1.53
Min all	0.65
75%ile all	1.03
25%ile all	0.97
50%ile all	1.00
Max 10	1.53
Min 10	0.65
75%ile 10	1.19
25%ile 10	1.00
50%ile 10	0.92

Table 3. Advice history table, showing calendar year catch divided by TAC and seasonal catch divided by advice (*or advice where no number was given in advice). In this stock, the fishing season and assessment year are from 1 April to 31 March, whilst the TAC is set on a calendar year basis.

Year	ICES Advice	Predicted catch consistent with advice	Agreed TAC	Official landings	Discards	ICES Catch	Calendar Catch/TAC	Seasonal Catch	Seasonal Catch/advice*
1987	Precautionary TAC	18	18	18	4.2	27.3	1.52	26.20	1.5
1988	TAC	13	18	17	2.4	19.2	1.07	20.45	1.6
1989	TAC	20	20	18	3.5	22.7	1.14	23.25	1.2
1990	TAC	15	17.5	17	2.5	20.2	1.15	18.40	1.2
1991	TAC (TAC excluding discards)	15 (12.5)	21	21	1.9	23.6	1.12	25.56	1.7
1992	TAC	27	21	19	2.1	23	1.10	21.13	0.8
1993	Precautionary TAC (including discards)	20–24	21	20	1.9	21.1	1.00	18.62	0.8
1994	Precautionary TAC (including discards)	20–24	21	19	1.7	19.1	0.91	19.30	0.8
1995	No specific advice	-	21	18	0.7	19.1	0.91	23.31	
1996	TAC	9.8	16.5–21 ²	21	3	21.8	1.04	18.82	1.9
1997	If required, precautionary TAC	< 25	22	20.7	0.7	18.8	0.85	20.50	0.8
1998	Catches below 25	< 25	22	20.5	0	20.3	0.92	18.04	0.7
1999	F = 0.4	19	21	19.4	0	18.1	0.86	18.49	1.0
2000	F < 0.3	20	21	18.8	0	18.3	0.87	17.19	0.9
2001	F < 0.34	17.9	20	19	0	17.7	0.89	15.27	0.9
2002	F < 0.35	11	11	11.5	0	10.6	0.96	7.47	0.7
2003	Substantially less than recent catches	-	13	12	0	10.9	0.84	11.54	
2004	60% of average catch 1997–2000	11	13	12	-	11.1	0.85	12.74	1.2
2005	60% of average catch 1997–2000	11	13	10	-	8.5	0.65	9.49	0.9
2006	Further reduction 60% avg. catch 2002–2004	6.7	11	9	-	8.5	0.77	6.94	1.0
2007	No fishing without rebuilding plan	--	9.4	9.6	-	8.3	0.88	7.64	0.8
2008	No targeted fishing without rebuilding plan	--	7.9	7.8	-	6.9	0.87	5.87	0.7
2009	No targeted fishing without rebuilding plan	--	5.9	6.2	-	5.8	0.98	5.75	1.0
2010	F _{msy} = 0.19	10.15	10.15	9.6	na	8.4	0.83	8.37	0.8
2011	See scenarios	-	13.2		na		0.00	11.47	0.9
2012	MSY Approach	26.8			na				

Table 4. Results of final simulation runs of the proposed rule, using most plausible settings, and testing for risk to both B_{lim} and $B_{changepoint}$, with and without the 30% TAC constraint.

				Median Values						
F target	B trig	% Const	Blim	F	TAC	SSB	Total Catch	Catch years 1-10	Catch years 11-21	Max Risk to low biomass
0.23	61000	0	26000	0.27	12499	56532	313677	173916	139761	1.1
0.23	61000	30	26000	0.25	11716	59810	300376	168637	131739	4
0.23	61000	0	39000	0.27	12499	56532	313677	173916	139761	10.8
0.23	61000	30	39000	0.25	11716	59810	300376	168637	131739	13.4

Table 5. Results of stress testing of the final simulation runs of the proposed rule, using most plausible settings, and testing for risk to both B_{lim} and $B_{changepoint}$, with and without the 30% TAC constraint.

				Median Values						
F target	B trig	% Const	Blim	F	TAC	SSB	Total Catch	Catch years 1-10	Catch years 11-21	Max Risk to low biomass
0.23	61000	0	26000	0.32	10449	45318	334346	198940	135406	12.6
0.23	61000	30	26000	0.32	9423	47456	303682	191601	112081	23.2
0.23	61000	0	39000	0.32	10449	45318	334346	198940	135406	40.1
0.23	61000	30	39000	0.32	9423	47456	303682	191601	112081	42.3

Table 6. Results of final simulation contrast run, with slight negative implementation bias, s of the proposed rule, using most plausible settings, and testing for risk to both B_{lim} and $B_{changepoint}$. This may be more representative of conditions in the fishery at present.

				Median Values						
F target	B trig	% Const	Blim	F	TAC	SSB	Total Catch	Catch years 1-10	Catch years 11-21	Max Risk to low biomass
0.23	61000	30	26000	0.22	14014	70229	301826	158991	139594	3.6
0.23	61000	30	39000	0.22	14014	70229	301826	158991	125635	3.6

Table 7. Results of illustrative runs, for several target Fs, without TAC constraint, and testing for risk to both B_{lim} and $B_{changepoint}$. This may be more representative of conditions in the fishery at present.

				Median Values						
F target	B trig	% Const	Blim	F	TAC	SSB	Total Catch	Catch years 1-10	Catch years 11-21	Max Risk to low biomass
0.25	61000	0	26000	0.33	13000	54183	335953	182055	126786	1.9
0.27	61000	0	26000	0.36	12985	51569	339908	185469	114079	4.3
0.29	61000	0	26000	0.39	13028	48368	341337	187724	139283	5.7

Table 8. Results for simulations using final settings, for the proposed HCR, modified with lower trigger biomasses.

				Median Values						
F target	B trig	% Const	Blim	F	TAC	SSB	Total Catch	Catch years 1-10	Catch years 11-21	Max Risk to low biomass
0.23	56000	0	26000	0.28	12206	59330	318110	172760	120058	3.4
0.23	51000	0	26000	0.29	12225	58751	319451	174553	108133	4.2
0.23	46000	0	26000	0.29	12135	57898	321653	175796	132530	3.2

Table 9. Mean F (2-5 ring) from 2012 assessment, and whether Subdivision VIIaS was closed (in borders). It can be seen that closures were associated with large reductions in F.

Open or Closed		F	Mean F	
1999 / 2000	Open	0.91		
2000 / 2001	Open	0.93	Open	0.68
2001 / 2002	Closed 16/1/02-23/2/02	0.84	Closed	0.36
2002 / 2003	Closed	0.34	Partially closed	0.65
2003 / 2004	Closed 1/4/02-1/12/03	0.46	Totally closed	0.21
2004 / 2005	Open	0.68		
2005 / 2006	Open	0.57		
2006 / 2007	Open	0.30		
2007 / 2008	Closed	0.24		
2008 / 2009	Closed	0.14		
2009 / 2010	Closed	0.10		
2010 / 2011	Closed	0.13		
2011 / 2012	Closed	0.15		

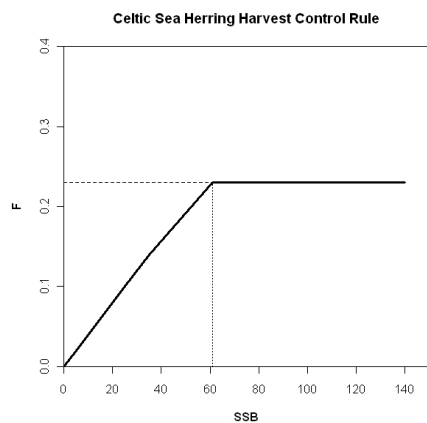


Figure 1: Schematic representation of the decision rule in the proposed long term management.

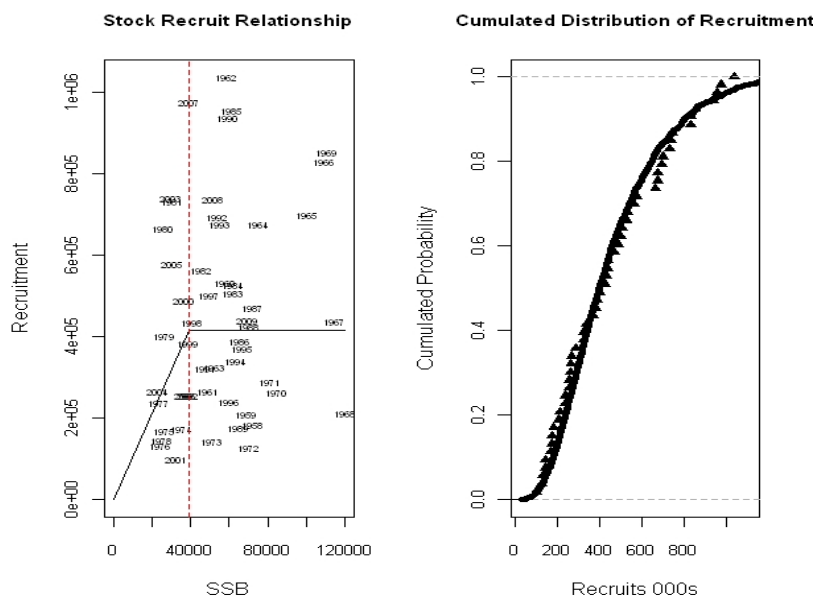


Figure 2. Left Panel: Segmented regression stock recruitment relationship. Right Panel: Stock recruit relationship cumulative distribution of observed and expected recruitments.

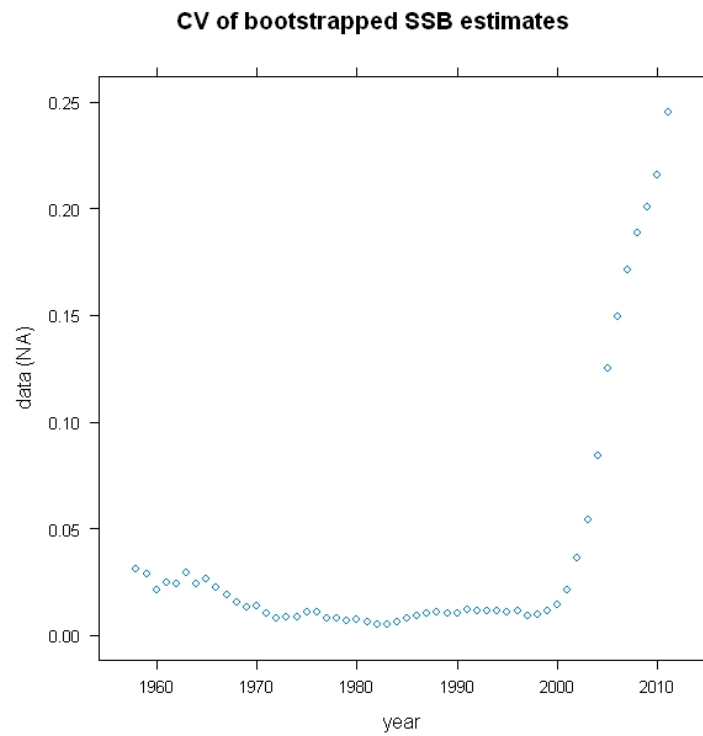


Figure 3. CV of bootstrapped SSB estimates from the observation model (ICES HAWG 2012 assessment).

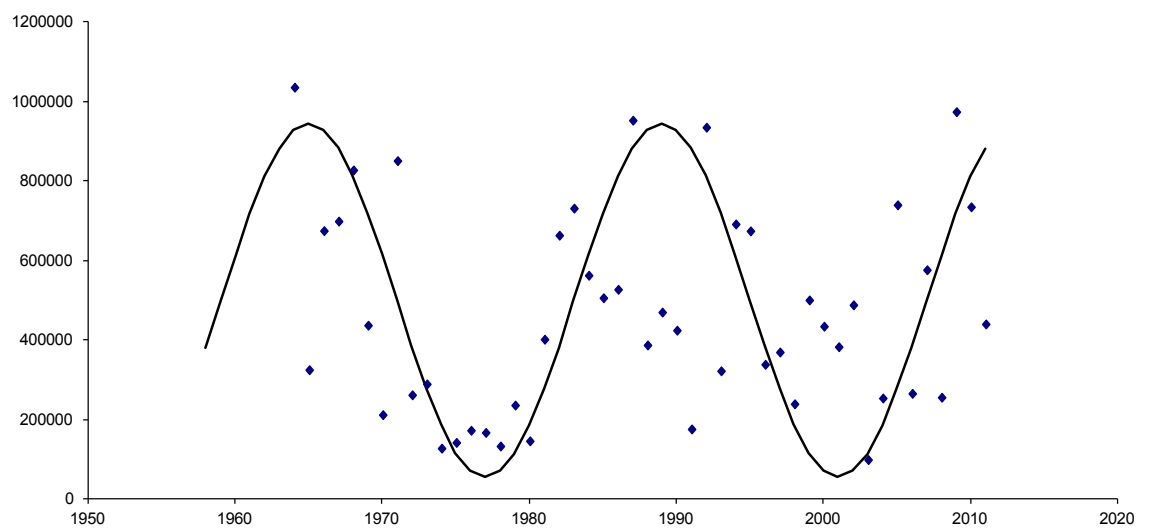


Figure 4. Cosine wave representing peaks and troughs in observed recruitment (by year class), in millions, displaying a 24 year period, amplitude of 0.8887639, and phase of 3.034, $r^2 = 0.09$.

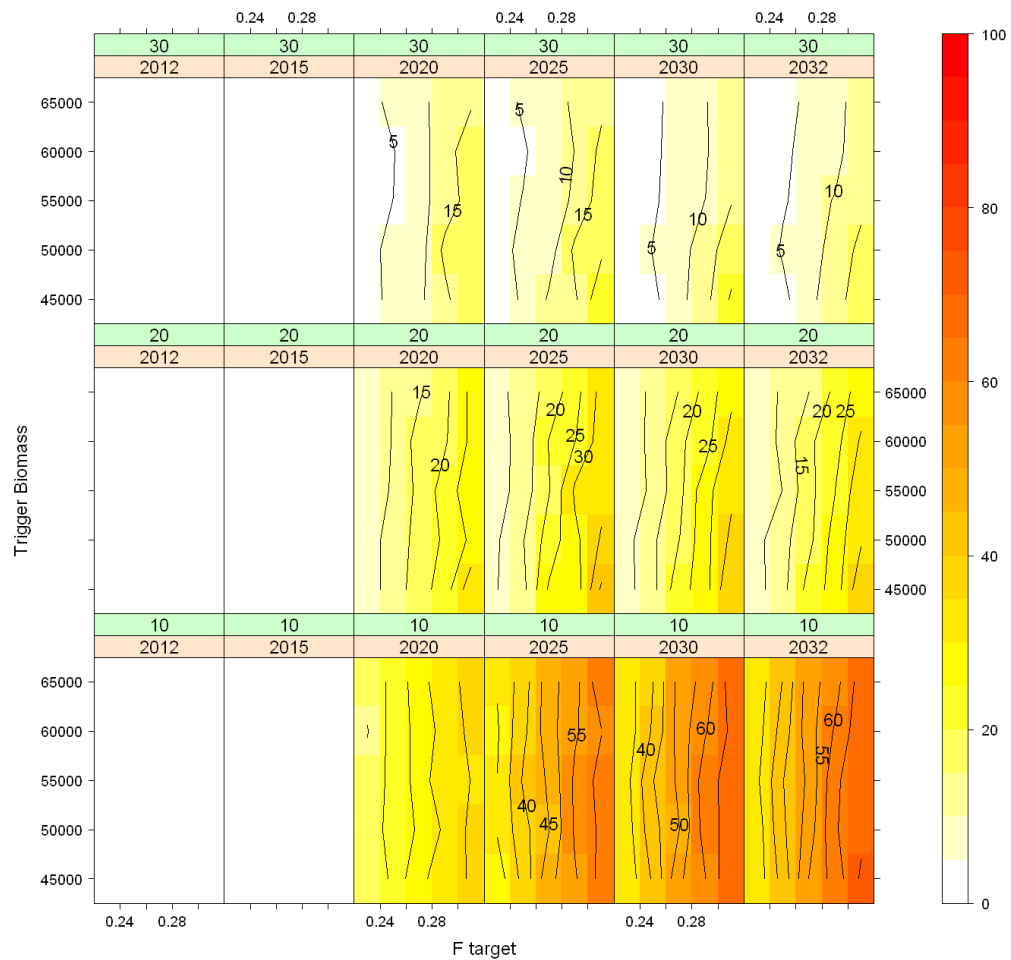


Figure 5. Risk profile (of breaching $B_{lim} = 26\,000\,t$) in any given year with 5% probability for a range of F targets, and percentage TAC constraints.

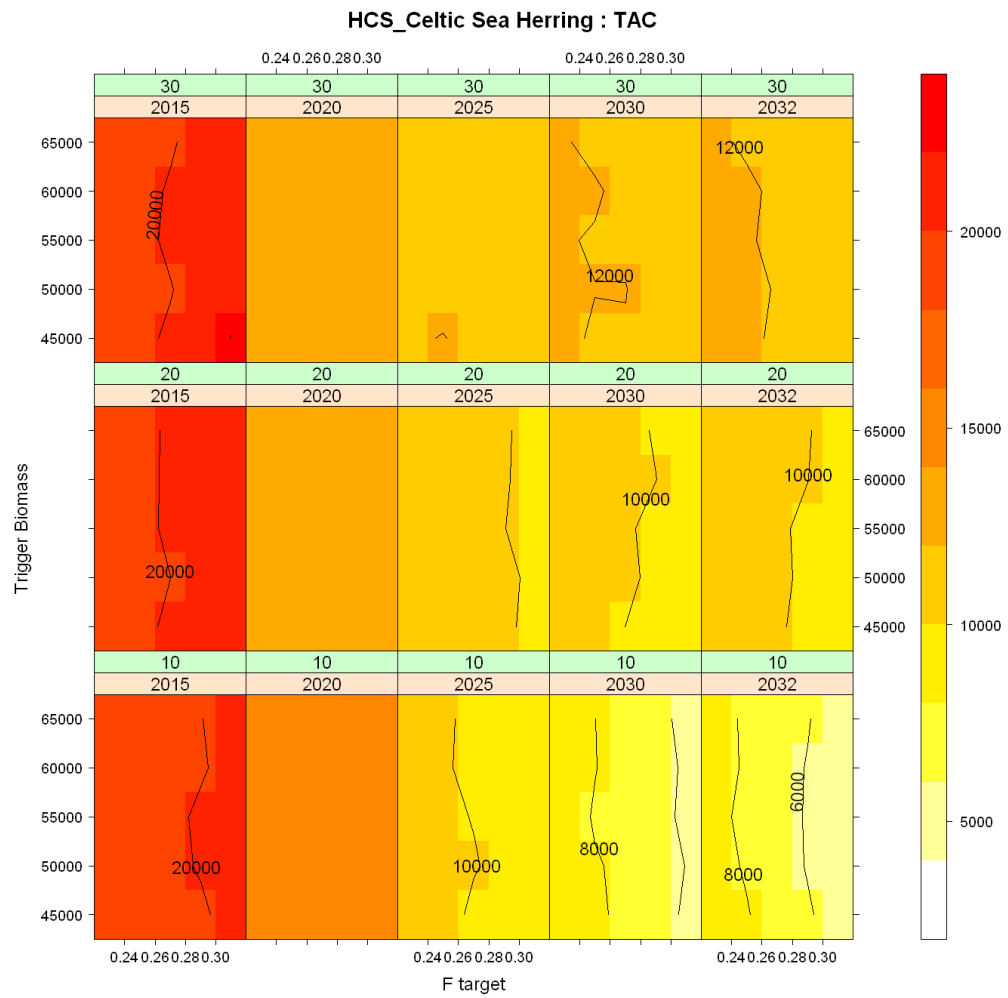


Figure 6. Range of likely TACs in any given year for a range of F targets, and percentage TAC constraints.

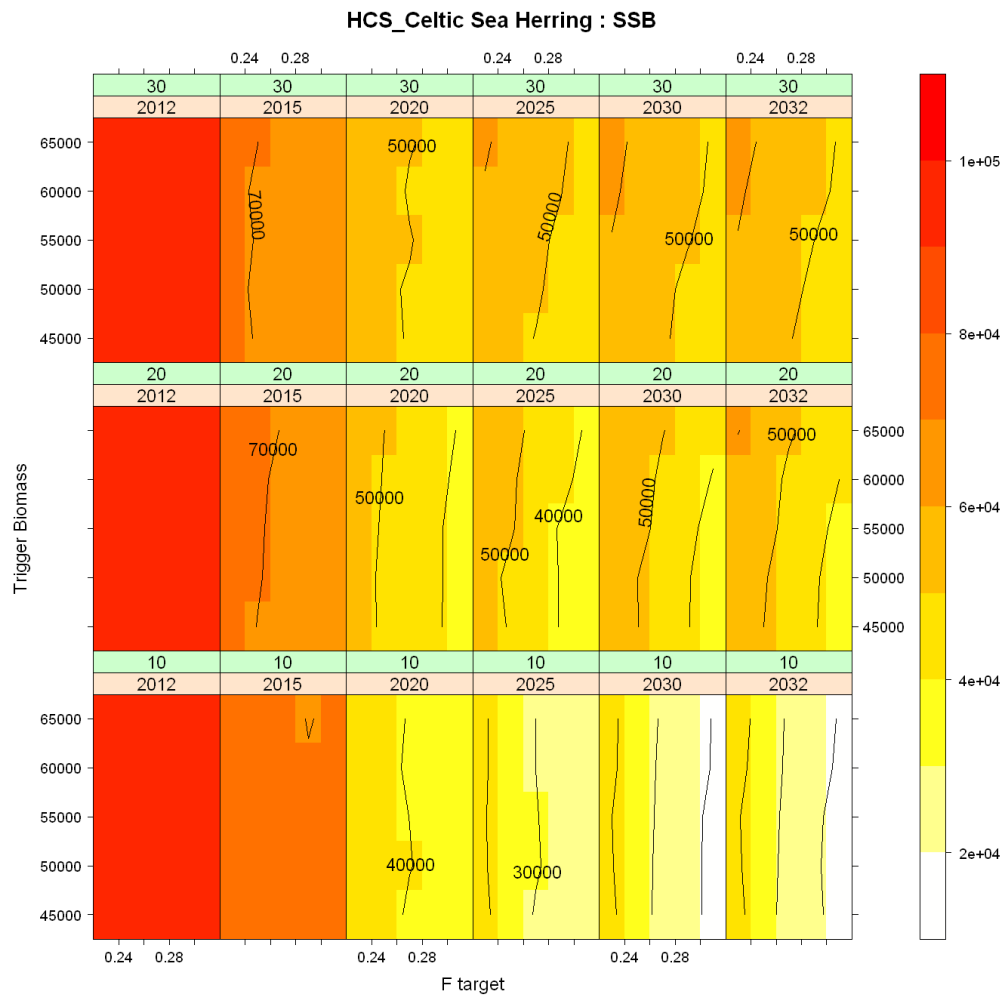
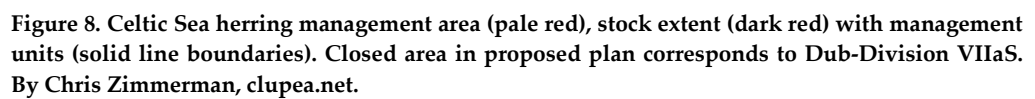


Figure 7. Range of likely SSB in any given year for a range of F targets, and percentage TAC constraints.



Annex 1: Results of simulations considering a broad range of implementation (Impl. CV) and bias (Impl. Bias, observation CV (Obs CV) and bias (Obs. Bias).

Also included are simulations using a cosine wave function for recruitment over time. Biomass trigger (Btrig), low biomass for risk evaluation (Blow), target F (Target) and realised catch indicated in table header.

Blow	Target	Btrig		Obs. Bias	Impl. Bias	Obs CV	Impl. CV
39142	0.23	61000		0	0	0.24	0
Year	F	SSB	Catch	TAC	AbsIAV	Plim	Pcrash
2012	0.226	93027	18236	18236	0	0.6	0
2013	0.225	98386	19563	19563	23	1	0
2014	0.25	86504	19208	19208	22.8	2.5	0
2015	0.265	76039	17653	17653	24.5	3	0
2016	0.265	72858	16628	16628	23.9	3.9	0
2017	0.263	67756	15274	15274	24.4	5	0
2018	0.254	66090	14242	14242	24.6	4.4	0
2019	0.241	65545	13389	13389	24.9	4.7	0
2020	0.236	65561	13101	13101	24.4	5.3	0
2021	0.232	65889	12917	12917	24.2	4.6	0
2022	0.232	66583	12993	12993	23.9	4.5	0
2023	0.231	66948	13002	13002	24.2	4.2	0
2024	0.23	66987	13077	13077	24	4	0
2025	0.224	67553	12855	12855	24.6	4.1	0
2026	0.225	67983	13010	13010	23.8	3.2	0
2027	0.224	68209	13004	13004	23.5	3.1	0
2028	0.224	68322	13079	13079	24.6	3.1	0
2029	0.224	68430	13093	13093	24.2	2.8	0
2030	0.225	68420	13138	13138	24.3	3.4	0
2031	0.224	68384	13103	13103	23.8	3.4	0
2032	0.228	68309	13332	13332	23.7	3.8	0

Blow	Target	Btrig1	Perc	Obs. bias	Impl. bias	CVobs	Impl. CV
39142	0.23	61000	30	0	0	0.34	0
Year	F	SSB	Catch	TAC	AbsIAV	Plim	Pcrash
2012	0.241	95766	18236	18236	0	3.3	0
2013	0.235	102305	19138	19138	24.4	4.5	0
2014	0.26	89931	19283	19283	25	5.6	0
2015	0.275	78810	18287	18287	26	6.8	0
2016	0.275	75559	17362	17362	25.4	7	0
2017	0.276	69005	15930	15931	26.1	6	0.1
2018	0.268	66451	14746	14746	26.1	6.8	0.1
2019	0.261	65270	13798	13799	26.1	8.3	0.2
2020	0.254	65127	13194	13194	25.6	7.5	0.2
2021	0.248	65323	12739	12739	25.8	7.4	0.3
2022	0.246	65527	12692	12693	25.4	7.4	0.3
2023	0.241	66149	12560	12560	25.5	7.4	0.3
2024	0.235	66876	12449	12449	25.3	7.1	0.3
2025	0.233	67238	12368	12369	25	6.7	0.4
2026	0.233	67554	12627	12628	24.8	7.3	0.5
2027	0.228	67708	12644	12644	25.6	6.7	0.6
2028	0.224	67880	12487	12488	25.1	6.6	0.6
2029	0.225	68033	12714	12715	25	5.2	0.6
2030	0.226	67720	12792	12792	25.1	5.4	0.6
2031	0.226	68016	12808	12808	25.3	6	0.6
2032	0.228	68451	12960	12960	25	5	0.6
Blow	Target	Btrig1	Perc	Obs. bias	Impl.	CVobs	Impl. CV

					bias		
39142	0.23	61000	30	0	0	0.44	0
Year	F	SSB	Catch	TAC	AbsIAV	Plim	Pcrash
2012	0.26	97600	18236	18236	0	7.7	0
2013	0.266	104677	18895	18896	26	8.5	0.2
2014	0.281	92673	18802	18803	26.5	8.9	0.4
2015	0.293	81070	18210	18211	26.2	10.5	0.5
2016	0.295	77463	17524	17524	26.7	10.7	0.5
2017	0.305	69273	16242	16244	27	12	0.8
2018	0.307	66233	15113	15117	26.8	11.6	1
2019	0.3	64308	13996	13998	26.7	13	1.1
2020	0.297	63627	13253	13254	26.5	14	1.3
2021	0.29	63773	12742	12747	26.7	12.2	1.7
2022	0.27	64777	12231	12233	26.8	12	1.9
2023	0.26	64941	12144	12146	26	11.7	1.9
2024	0.253	65365	12079	12080	26.2	12.5	2
2025	0.242	65956	11969	11969	26.4	10.9	2
2026	0.235	66483	12000	12000	26.6	10.6	2
2027	0.227	66954	11865	11865	26.3	10.7	2
2028	0.224	67809	11964	11964	26.2	9.4	2
2029	0.224	68210	12170	12170	26.2	9.3	2
2030	0.227	68391	12364	12364	25.8	10.2	2
2031	0.23	68572	12613	12612	25.8	8.1	2
2032	0.231	68419	12715	12715	25.8	8.1	2

					Impl.		
Blow	Target	Btrig1	Perc	Obs. bias	bias	CVobs	Impl. CV
39142	0.23	61000	30	-0.03	0	0	0
Year	F	SSB	Catch	TAC	AbsIAV	Plim	Pcrash
2012	0.23	85288	18236	18236	0	0	0
2013	0.229	89230	19208	19208	15.7	0	0
2014	0.237	79401	17406	17405	20.5	0	0
2015	0.237	71864	15466	15466	20.4	0.3	0
2016	0.228	70757	14577	14577	19.6	0.5	0
2017	0.223	68523	13738	13738	20.6	0.5	0
2018	0.22	68085	13436	13436	20	0.8	0
2019	0.218	67924	13160	13160	20.2	1	0
2020	0.217	67887	13124	13124	20.1	0.5	0
2021	0.215	68023	12989	12989	20.1	0.9	0
2022	0.214	68569	13049	13049	20.4	0.5	0
2023	0.217	68700	13254	13254	20.1	0.5	0
2024	0.216	68585	13189	13188	20.7	0.8	0
2025	0.214	68840	13146	13146	20.6	0.4	0
2026	0.215	69050	13254	13254	20.1	0.9	0
2027	0.216	68987	13244	13244	20.2	0.5	0
2028	0.216	68885	13248	13248	20.4	0.3	0
2029	0.218	68751	13339	13339	20.3	0.6	0
2030	0.215	68617	13155	13155	20.7	0.7	0
2031	0.215	68674	13114	13114	20.8	0.9	0
2032	0.217	68701	13309	13309	19.5	1	0

Blow	Target	Btrig1	Perc	Obs. bias	Impl. bias	CVobs	Impl. CV
39142	0.23	61000	30	0.03	0	0	0
Year	F	SSB	Catch	TAC	AbsIAV	Plim	Pcrash
2012	0.214	91872	18236	18236	0	0	0
2013	0.235	96009	21279	21278	17.9	0	0
2014	0.257	82848	19971	19971	18.3	0	0
2015	0.261	73125	17307	17307	21	0.2	0
2016	0.257	70874	16320	16320	19.6	0.8	0
2017	0.254	66738	15011	15011	21.1	1	0
2018	0.249	65255	14340	14340	21.4	1	0
2019	0.245	64422	13891	13891	20.2	1.9	0
2020	0.238	64349	13425	13425	21.3	1.8	0
2021	0.236	64388	13310	13310	21	1.8	0
2022	0.237	64292	13325	13325	20.1	1.8	0
2023	0.235	64535	13237	13237	21	1.5	0
2024	0.235	64832	13332	13332	20.5	1.6	0
2025	0.235	64748	13293	13293	20.8	2.3	0
2026	0.235	64735	13310	13310	20.8	2.4	0
2027	0.235	64668	13375	13375	20.9	2.9	0
2028	0.235	64662	13286	13286	20.7	2	0
2029	0.236	64632	13377	13377	20.4	1.8	0
2030	0.235	64309	13291	13290	20.8	1.4	0
2031	0.234	64688	13246	13246	20.2	1.9	0
2032	0.234	65330	13303	13303	20	1.8	0

Blow	Target	Btrig1	Perc	Obs. bias	Impl. bias	CVobs	Impl. CV
39142	0.23	61000	30	-0.35	0	0	0
Year	F	SSB	Catch	TAC	AbsIAV	Plim	Pcrash
2012	0.367	53468	18236	18236	0	1.8	0
2013	0.273	55726	12818	12818	35	5.9	0
2014	0.21	56709	9253	9253	33.5	9.5	0
2015	0.149	60345	7230	7230	30.3	7.2	0
2016	0.114	68260	6781	6781	25.7	3.2	0
2017	0.101	76195	7120	7120	23	1.3	0
2018	0.103	81518	7925	7925	21.5	0.6	0
2019	0.106	85257	8614	8614	21.9	0.2	0
2020	0.11	87934	9259	9259	21.3	0	0
2021	0.114	89808	9772	9772	21	0	0
2022	0.117	91513	10276	10276	21.2	0	0
2023	0.121	92295	10710	10710	20.7	0	0
2024	0.122	92561	10835	10835	21.4	0	0
2025	0.122	93126	10938	10938	20.8	0	0
2026	0.123	93449	11088	11088	20.3	0	0
2027	0.124	93442	11115	11115	20.4	0	0
2028	0.124	93394	11166	11166	20.4	0	0
2029	0.125	93315	11225	11225	21.2	0	0
2030	0.124	93232	11110	11110	20.6	0	0
2031	0.124	93183	11102	11102	20.7	0	0
2032	0.125	93247	11223	11223	19.6	0	0

Blow	Target	Btrig1	Perc	Obs. bias	Impl. bias	CVobs	Impl. CV
39142	0.23	61000	30	0.53	0	0	0
Year	F	SSB	Catch	TAC	AbsIAV	Plim	Pcrash
2012	0.139	140659	18236	18236	0	0	0
2013	0.159	152427	23707	23707	26.1	0	0
2014	0.247	126995	30791	30791	26	0	0
2015	0.403	94873	36357	36357	19.7	0	0
2016	0.508	72732	32992	32992	21.1	2.7	0
2017	0.61	52573	25943	25944	27.2	19.5	0.1
2018	0.686	43771	20796	20810	27	38.8	1.4
2019	0.685	39929	17010	17025	26.2	50.8	2.6
2020	0.651	38171	15037	15050	24.1	52.2	3.3
2021	0.6	37460	13783	13789	23.8	56.2	3.9
2022	0.558	37352	13094	13097	23.6	55.5	4.1
2023	0.53	37168	12759	12762	23.2	55.3	4.4
2024	0.508	36896	12444	12447	23.1	56.6	4.7
2025	0.479	36970	12124	12126	23.5	56.6	5
2026	0.464	37089	12081	12081	23.1	56.5	5
2027	0.448	37127	11946	11948	22.7	57.5	5.1
2028	0.432	37237	11827	11827	23.6	55.9	5.3
2029	0.43	37444	11907	11907	22.5	55.4	5.3
2030	0.424	37662	11783	11783	23.4	56.2	5.3
2031	0.418	38175	11843	11843	23.6	54.5	5.4
2032	0.418	38349	12150	12150	22.6	53.5	5.4

Blow	Target	Btrig1	Perc	Obs. bias	Impl. bias	CVobs	Impl. CV
39142	0.23	61000	30	-0.08	0	0	0
Year	F	SSB	Catch	TAC	AbsIAV	Plim	Pcrash
2012	0.244	80331	18236	18236	0	0	0
2013	0.218	84555	17217	17217	17.6	0	0
2014	0.219	77164	15558	15558	21	0	0
2015	0.217	71560	14037	14037	20.8	0.1	0
2016	0.208	71739	13492	13492	19.7	0.5	0
2017	0.203	70647	12968	12968	20.6	0.1	0
2018	0.201	70708	12881	12881	20.1	0.4	0
2019	0.2	70805	12742	12742	20.4	0.5	0
2020	0.2	70913	12779	12779	20	0.1	0
2021	0.198	71110	12700	12700	20	0.4	0
2022	0.199	71679	12797	12796	20.3	0.1	0
2023	0.201	71801	13015	13014	20.2	0.3	0
2024	0.2	71671	12952	12952	20.8	0.3	0
2025	0.199	71925	12909	12909	20.5	0	0
2026	0.2	72124	13015	13015	20	0.2	0
2027	0.2	72057	13001	13001	20.2	0.2	0
2028	0.2	71955	13007	13007	20.3	0	0
2029	0.202	71824	13092	13092	20.3	0.2	0
2030	0.2	71695	12914	12914	20.6	0.1	0
2031	0.199	71732	12880	12880	20.7	0.4	0
2032	0.202	71761	13069	13069	19.5	0.4	0

Blow	Target	Btrig1	Perc	Obs. bias	Impl. bias	CVobs	Impl. CV
39142	0.23	61000	30	0.16	0	0	0
Year	F	SSB	Catch	TAC	AbsIAV	Plim	Pcrash
2012	0.188	104818	18236	18236	0	0	0
2013	0.225	110135	23445	23445	25	0	0
2014	0.29	91502	25250	25249	16.2	0	0
2015	0.314	75766	21814	21814	21.3	0.3	0
2016	0.318	69444	19662	19662	20.5	1.5	0
2017	0.321	62066	17195	17195	21.9	3.6	0
2018	0.314	59102	15800	15800	22	5.5	0
2019	0.305	57517	14829	14828	20.9	7.3	0
2020	0.293	57208	14027	14027	21.9	8.4	0
2021	0.286	57245	13723	13723	21.4	8.7	0
2022	0.284	57260	13656	13656	20.4	9	0
2023	0.281	57604	13559	13559	21.4	7.8	0
2024	0.28	57948	13659	13659	20.8	8.4	0
2025	0.281	57951	13649	13649	21	9.1	0
2026	0.28	57961	13660	13660	21	8.9	0
2027	0.28	57883	13740	13739	21.2	8.2	0
2028	0.28	57903	13677	13676	21.2	8.7	0
2029	0.282	57852	13764	13764	20.6	7.6	0
2030	0.28	57525	13676	13676	21.2	8.1	0
2031	0.279	57871	13618	13618	20.7	7.2	0
2032	0.279	58489	13702	13702	20.4	6.7	0

Blow	Target	Btrig1	Perc	Obs. bias	Impl. bias	CVobs	Impl. CV
39142	0.23	61000	30	0	0	0	-0.3
Year	F	SSB	Catch	TAC	AbsIAV	Plim	Pcrash
2012	0.222	88261	18236	18236	0	0	0
2013	0.252	91380	21364	20321	16.4	0	0
2014	0.273	79257	19371	18546	19.9	0.2	0
2015	0.281	70046	17055	16259	21.2	2.1	0
2016	0.266	67823	15563	15015	20.5	3.4	0
2017	0.262	64756	14608	13922	21.6	4.4	0
2018	0.254	64039	13794	13348	21.1	4.4	0
2019	0.251	63844	13528	12912	21.4	4.8	0
2020	0.249	63713	13544	12845	20.7	4.9	0
2021	0.244	63907	13180	12667	20.9	4.3	0
2022	0.246	64469	13299	12711	21.2	4.6	0
2023	0.244	64739	13399	12889	21.3	5.3	0
2024	0.245	64656	13493	12833	21.6	4.8	0
2025	0.246	64817	13438	12862	21.2	4.8	0.1
2026	0.248	64899	13681	12936	21.3	3.1	0.1
2027	0.245	64831	13445	12892	21.1	3.4	0.1
2028	0.244	64828	13421	12838	21.1	3.6	0.1
2029	0.25	64764	13680	12969	20.8	4.2	0.1
2030	0.24	64715	13252	12827	21.5	4.2	0.1
2031	0.247	64733	13549	12828	21.4	4.6	0.1
2032	0.25	64573	13700	12985	20.5	4.4	0.1

Blow	Target	Btrig1	Perc	Obs. bias	Impl. bias	CVobs	Impl. CV
39142	0.23	61000	30	0	0	0	-0.2
Year	F	SSB	Catch	TAC	AbsIAV	Plim	Pcrash
2012	0.221	88882	18236	18236	0	0	0
2013	0.241	92674	20850	20306	16.3	0	0
2014	0.26	80460	19293	18801	18.9	0	0
2015	0.259	71844	16508	16341	21.2	1	0
2016	0.254	70342	15747	15463	20.2	1.9	0
2017	0.254	66807	14846	14376	20.9	2	0
2018	0.251	65442	14347	13848	21.9	1.6	0
2019	0.244	64660	13740	13446	20.4	2.6	0
2020	0.234	64804	13144	13010	21.4	3.2	0
2021	0.234	64995	13192	12927	21	2.5	0
2022	0.236	64927	13334	12961	20.6	2.4	0
2023	0.236	65076	13286	12871	20.9	2.1	0
2024	0.236	65287	13361	12973	21	2.9	0
2025	0.231	65293	13086	12946	21.4	3.3	0
2026	0.233	65349	13225	12935	21.1	3	0
2027	0.233	65350	13330	13028	21.4	2.9	0
2028	0.234	65306	13245	12938	21.1	2.6	0
2029	0.235	65287	13347	13062	20.4	2.2	0
2030	0.235	64920	13256	12980	20.9	2.3	0
2031	0.233	65334	13120	12893	20.2	2.9	0
2032	0.234	66018	13300	13001	20.5	2.4	0

Blow	Target	Btrig1	Perc	Obs. bias	Impl. bias	CVobs	Impl. CV
39142	0.23	61000	30	0	0	0	-0.1
Year	F	SSB	Catch	TAC	AbsIAV	Plim	Pcrash
2012	0.221	89480	18236	18236	0	0	0
2013	0.237	93652	20672	20350	16.9	0	0
2014	0.248	81836	18886	18772	19.7	0	0
2015	0.251	72814	16574	16478	21.5	0.2	0
2016	0.242	71565	15534	15489	20.2	1.1	0
2017	0.242	67677	14547	14490	21.1	1.3	0
2018	0.238	66617	14061	13998	20.1	1.3	0
2019	0.232	65990	13513	13440	20.9	1.2	0
2020	0.227	65973	13193	13156	20.6	0.9	0
2021	0.229	66239	13262	13252	20.5	1.2	0
2022	0.226	66908	13209	13243	20.7	1.9	0
2023	0.23	66440	13465	13367	21	1.5	0
2024	0.23	66044	13393	13358	20.5	2.5	0
2025	0.228	65982	13275	13234	20.9	1.9	0
2026	0.229	65823	13278	13200	20.3	2.2	0
2027	0.229	65733	13238	13076	20.4	1.5	0
2028	0.227	65969	13118	13030	20.5	1.8	0
2029	0.229	66111	13280	13212	20.5	1.4	0
2030	0.228	66017	13256	13201	21	1.1	0
2031	0.228	66205	13290	13202	20.9	1.2	0
2032	0.228	66256	13270	13199	20.4	1.3	0

Blow	Target	Btrig1	Perc	Obs. bias	Impl. bias	CVobs	Impl. CV
39142	0.23	61000	30	0	0	0	0.1
Year	F	SSB	Catch	TAC	AbsIAV	Plim	Pcrash
2012	0.222	88966	18236	18236	0	0	0
2013	0.235	93404	20417	20263	15.8	0	0
2014	0.249	81951	18919	18779	19.1	0	0
2015	0.254	72682	16736	16631	21	1	0
2016	0.246	71255	15678	15558	20.2	1.7	0
2017	0.244	67744	14631	14588	20.6	1.4	0
2018	0.237	66598	13881	13866	21.3	1.9	0
2019	0.229	66301	13396	13401	20.8	1.6	0
2020	0.23	66184	13487	13437	20.2	1.2	0
2021	0.23	65651	13316	13256	20.5	1.3	0
2022	0.228	66035	13230	13155	20.4	2.2	0
2023	0.226	66067	13093	13044	20.8	2	0
2024	0.228	65876	13206	13190	20.7	1.9	0
2025	0.228	66087	13276	13200	20.9	1.8	0
2026	0.23	66374	13400	13345	20.7	1.6	0
2027	0.232	66092	13454	13360	20.2	1.9	0
2028	0.229	66330	13297	13242	20.5	1.6	0
2029	0.227	66717	13320	13278	20.1	1.4	0
2030	0.227	66522	13312	13310	21.2	1.9	0
2031	0.229	66983	13408	13316	20	1.7	0
2032	0.231	67300	13592	13425	20.5	2.1	0

Blow	Target	Btrig1	Perc	Obs. bias	Impl. bias	CVobs	Impl. CV
39142	0.23	61000	30	0	0	0	0.2
Year	F	SSB	Catch	TAC	AbsIAV	Plim	Pcrash
2012	0.222	88865	18236	18236	0	0	0
2013	0.24	92792	20704	20231	16.4	0	0
2014	0.255	81199	19046	18510	19.8	0	0
2015	0.26	72511	16762	16442	21.2	0.8	0
2016	0.256	70631	15879	15453	20.1	1.9	0
2017	0.251	67190	14649	14313	21.6	2	0
2018	0.251	66189	14349	13936	20.4	2.8	0
2019	0.242	65543	13753	13454	21	3.2	0
2020	0.24	65405	13578	13288	20.9	3.3	0
2021	0.237	65807	13470	13222	20.2	2.8	0
2022	0.232	66012	13216	13146	20.8	2.5	0
2023	0.233	65746	13421	13160	20.6	2.6	0
2024	0.233	65273	13396	13165	20.7	2.7	0
2025	0.234	65538	13337	13019	21.1	2.4	0
2026	0.237	65398	13430	13039	20.7	2.6	0
2027	0.237	65107	13433	13035	21.4	2	0
2028	0.235	65158	13305	13029	20.2	2.5	0
2029	0.238	65471	13448	13044	21.4	3	0
2030	0.235	65524	13225	13099	20.1	3	0
2031	0.234	65953	13362	13109	20.9	3.9	0
2032	0.235	65803	13443	13157	21	2.9	0

Blow	Target	Btrig1	Perc	Obs. bias	Impl. bias	CVobs	Impl. CV
39142	0.23	61000	30	0	0	0	0.3
Year	F	SSB	Catch	TAC	AbsIAV	Plim	Pcrash
2012	0.22	89271	18236	18236	0	0	0
2013	0.249	92886	21351	20298	15.9	0	0
2014	0.267	80628	19363	18756	19.1	0.3	0
2015	0.284	71043	17429	16427	21.6	2.7	0
2016	0.272	68873	15928	15400	20.8	4.5	0
2017	0.27	65257	14895	14335	21.3	5.3	0
2018	0.26	64102	14032	13436	21.6	4.8	0
2019	0.258	63844	13861	13198	21.1	4.8	0
2020	0.249	63643	13425	12983	20.7	5.2	0
2021	0.25	63772	13470	12858	21.3	5.3	0
2022	0.252	63773	13509	12762	21.4	4.9	0
2023	0.252	63749	13298	12679	21.7	5.6	0.2
2024	0.244	64148	13003	12626	21.4	4.9	0.2
2025	0.25	64532	13455	12600	21.4	5.1	0.2
2026	0.243	64515	13171	12619	21.5	5.6	0.3
2027	0.245	64693	13260	12790	21.9	5.5	0.3
2028	0.249	64631	13586	12878	21.8	4.3	0.3
2029	0.239	64791	13018	12798	21.6	4.2	0.3
2030	0.25	64565	13522	12850	21.5	4.7	0.3
2031	0.245	64266	13307	12805	21.4	4.5	0.3
2032	0.249	64099	13514	12879	21.1	4.3	0.3

Blow	Target	Btrig1	Perc	Obs. bias	Impl. bias	CVobs	Impl. CV
39142	0.23	61000	30	0	-0.3	0	0
Year	F	SSB	Catch	TAC	AbsIAV	Plim	Pcrash
2012	0.222	88261	18236	18236	0	0	0
2013	0.157	95669	14225	20321	16.4	0	0
2014	0.151	90245	12982	18546	19.9	0	0
2015	0.151	85261	12139	17342	18.1	0	0
2016	0.147	86716	12021	17173	17.4	0	0
2017	0.146	84872	11725	16750	18.3	0	0
2018	0.147	84870	11789	16841	17.7	0.1	0
2019	0.146	84807	11652	16645	17.9	0	0
2020	0.147	84823	11715	16735	17.6	0	0
2021	0.146	84883	11621	16602	17.6	0	0
2022	0.146	85405	11732	16760	18.5	0	0
2023	0.148	85474	11868	16954	17.8	0	0
2024	0.147	85349	11787	16838	18.4	0	0
2025	0.146	85660	11776	16822	17.7	0	0
2026	0.147	85859	11843	16918	18	0	0
2027	0.146	85804	11816	16879	18	0	0
2028	0.147	85752	11834	16905	17.8	0	0
2029	0.147	85663	11895	16993	18.4	0	0
2030	0.146	85557	11761	16802	18.4	0	0
2031	0.146	85532	11767	16810	17.9	0	0
2032	0.148	85598	11868	16954	17.5	0.1	0

Blow	Target	Btrig1	Perc	Obs. bias	Impl. bias	CVobs	Impl. CV
39142	0.23	61000	30	0	-0.2	0	0
Year	F	SSB	Catch	TAC	AbsIAV	Plim	Pcrash
2012	0.221	88882	18236	18236	0	0	0
2013	0.181	95434	16245	20306	16.3	0	0
2014	0.181	87610	15041	18801	18.9	0	0
2015	0.18	81582	13638	17047	19.1	0	0
2016	0.177	82402	13551	16938	18.1	0.1	0
2017	0.176	79517	12985	16231	19.4	0	0
2018	0.174	78786	12752	15940	19.9	0	0
2019	0.174	78283	12663	15829	18.4	0	0
2020	0.172	78129	12410	15513	19.3	0.2	0
2021	0.172	78002	12351	15439	19	0.2	0
2022	0.173	77715	12396	15494	18.5	0.2	0
2023	0.172	77794	12320	15400	19.1	0.2	0
2024	0.172	78004	12367	15459	19	0.1	0
2025	0.171	77797	12294	15367	19.4	0	0
2026	0.172	77747	12315	15393	19.1	0	0
2027	0.172	77695	12363	15454	19	0.1	0
2028	0.172	77627	12272	15339	18.8	0.2	0
2029	0.172	77639	12355	15444	18.7	0.2	0
2030	0.172	77259	12284	15355	18.9	0	0
2031	0.172	77631	12271	15338	18.3	0	0
2032	0.171	78272	12271	15338	18.2	0.1	0

Blow	Target	Btrig1	Perc	Obs. bias	Impl. bias	CVobs	Impl. CV
39142	0.23	61000	30	0	-0.1	0	0
Year	F	SSB	Catch	TAC	AbsIAV	Plim	Pcrash
2012	0.221	89480	18236	18236	0	0	0
2013	0.206	95063	18315	20350	16.9	0	0
2014	0.211	85387	16895	18772	19.7	0	0
2015	0.211	77599	15150	16833	20.3	0	0
2016	0.205	77471	14580	16200	19.2	0	0
2017	0.206	73650	13860	15400	20.2	0.4	0
2018	0.204	72712	13527	15030	19.1	0.1	0
2019	0.199	72058	13084	14537	19.9	0	0
2020	0.197	71938	12879	14310	19.6	0.3	0
2021	0.201	71963	13001	14445	19.4	0.3	0
2022	0.199	72430	12942	14380	19.9	0	0
2023	0.2	71865	13035	14483	19.7	0.2	0
2024	0.2	71473	12998	14442	19.7	0.2	0
2025	0.199	71404	12860	14289	19.9	0.4	0
2026	0.199	71258	12826	14251	19.2	0.3	0
2027	0.198	71219	12725	14138	19.6	0.4	0
2028	0.197	71529	12683	14093	19.7	0.5	0
2029	0.199	71683	12855	14283	19.7	0.3	0
2030	0.199	71547	12885	14316	20.1	0	0
2031	0.198	71713	12849	14276	19.8	0.1	0
2032	0.199	71726	12872	14302	19.6	0.2	0

Blow	Target	Btrig1	Perc	Obs. bias	Impl. bias	CVobs	Impl. CV
39142	0.23	61000	30	0	0.1	0	0
Year	F	SSB	Catch	TAC	AbsIAV	Plim	Pcrash
2012	0.222	88966	18236	18236	0	0	0
2013	0.259	92287	22289	20263	15.8	0	0
2014	0.283	79027	20657	18779	19.1	0.1	0
2015	0.292	68665	17967	16333	21.9	1.4	0
2016	0.283	66305	16473	14976	21	2.3	0
2017	0.281	62642	15212	13829	21.3	3	0
2018	0.271	61396	14301	13001	22.1	4.6	0
2019	0.261	61132	13710	12464	21.7	3.5	0
2020	0.26	61100	13689	12445	20.9	3.2	0
2021	0.257	60775	13469	12244	21.5	3.6	0
2022	0.254	61335	13369	12153	21.3	4.2	0
2023	0.252	61555	13284	12077	21.5	4.3	0
2024	0.254	61443	13440	12218	21.4	4.2	0
2025	0.253	61755	13470	12246	21.8	3.9	0
2026	0.255	62075	13661	12419	21.4	4	0
2027	0.258	61829	13745	12495	20.8	4.3	0
2028	0.256	62024	13639	12399	21.2	4	0
2029	0.255	62331	13660	12418	20.9	3	0
2030	0.255	62097	13670	12427	21.8	4.2	0
2031	0.255	62563	13659	12417	20.6	4.1	0
2032	0.256	62970	13762	12511	21.2	3.4	0

Blow	Target	Btrig1	Perc	Obs. bias	Impl. bias	CVobs	Impl. CV
39142	0.23	61000	30	0	0.2	0	0
Year	F	SSB	Catch	TAC	AbsIAV	Plim	Pcrash
2012	0.222	88865	18236	18236	0	0	0
2013	0.286	90661	24277	20231	16.4	0	0
2014	0.321	75705	22212	18510	19.8	0	0
2015	0.336	65018	19033	15861	22.8	2.1	0
2016	0.328	61558	17205	14337	21.8	5	0
2017	0.325	58055	15481	12901	23.1	6.3	0.2
2018	0.318	57093	14716	12264	22.1	7.7	0.2
2019	0.305	56749	14085	11737	22.8	9.1	0.2
2020	0.298	56946	13808	11506	22.1	9.5	0.2
2021	0.29	57573	13748	11457	21.8	8.8	0.2
2022	0.286	57841	13719	11432	22.2	9.3	0.2
2023	0.284	57583	13782	11485	22	8.3	0.3
2024	0.285	57070	13804	11504	22.2	10	0.3
2025	0.284	57339	13683	11403	22.4	10.1	0.3
2026	0.284	57385	13654	11378	21.9	10.1	0.3
2027	0.283	57322	13641	11368	22.5	8.7	0.3
2028	0.281	57505	13610	11341	21.9	9.3	0.3
2029	0.284	57821	13741	11451	22.2	7.8	0.3
2030	0.288	57820	13833	11527	21.3	9.2	0.3
2031	0.286	58097	13831	11526	22.1	9.3	0.3
2032	0.286	57931	13883	11569	22.2	9.5	0.3

Blow	Target	Btrig1	Perc	Obs. bias	Impl. bias	CVobs	Impl. CV
39142	0.23	61000	30	0	0.3	0	0
Year	F	SSB	Catch	TAC	AbsIAV	Plim	Pcrash
2012	0.22	89271	18236	18236	0	0	0
2013	0.313	89898	26387	20298	15.9	0	0
2014	0.37	72483	24383	18756	19.1	0.6	0
2015	0.398	60101	20385	15680	24	7.3	0
2016	0.394	55706	17909	13776	23.1	12.4	0
2017	0.389	51994	15969	12285	23.1	17.6	0.1
2018	0.372	50932	14520	11170	23.7	20.2	0.1
2019	0.351	51159	13880	10678	23.2	20	0.2
2020	0.338	51493	13618	10476	22.9	17.7	0.3
2021	0.33	51965	13469	10361	22.9	19.2	0.3
2022	0.323	52483	13383	10294	22.6	17.3	0.3
2023	0.322	52923	13352	10271	23	18.7	0.3
2024	0.32	53495	13348	10269	23.1	17.4	0.4
2025	0.318	54055	13460	10354	23.3	16.6	0.4
2026	0.316	54259	13470	10362	22.9	15.6	0.4
2027	0.319	54383	13644	10496	23.2	15.4	0.4
2028	0.321	54304	13829	10638	22.7	13.9	0.4
2029	0.318	54205	13811	10624	22.8	12.9	0.4
2030	0.32	53908	13813	10626	22.9	15.1	0.4
2031	0.32	53639	13713	10549	22.9	14.4	0.4
2032	0.323	53607	13800	10615	22.7	14.5	0.4

cosine	Blow	Target	Btrig1	Perc	Obs. bias	Impl. bias	CVobs	Impl. CV
	39142	0.23	61000	30	0.03	0.1	0.24	0.1
	Year	F	SSB	Catch	TAC	AbsIAV	Plim	Pcrash
	2012	0.219	96142	18236	18236	0	0.4	0
	2013	0.248	106925	22172	20120	22.9	0.5	0
	2014	0.283	101484	23066	20875	22.3	0.5	0
	2015	0.292	97406	22708	20578	23.4	0.3	0
	2016	0.292	100828	23117	20889	22.6	0.6	0
	2017	0.284	104410	23404	21164	23	0.4	0
	2018	0.279	106830	23803	21466	23.2	0.5	0
	2019	0.274	108592	24079	21793	23.1	0.2	0
	2020	0.28	107465	24746	22411	22.8	0.2	0
	2021	0.293	102874	25100	22689	23.2	0.7	0
	2022	0.307	95456	24809	22484	23.1	0.7	0
	2023	0.33	84688	23621	21336	23.7	2.1	0
	2024	0.355	71816	21566	19561	24.1	5.1	0.3
	2025	0.385	58593	18910	17092	26.6	14.6	0.6
	2026	0.439	45145	16028	14562	27.3	35.1	1.7
	2027	0.529	32779	12748	11526	30.5	69.3	3.6
	2028	0.681	22305	9560	8670	34.9	93.6	8.5
	2029	0.892	14541	6588	6025	41.6	99.7	18.1
	2030	1.159	9502	4336	3941	50.6	100	31.9
	2031	1.352	6703	2716	2480	55.6	100	44.1
	2032	1.399	5519	1777	1618	51.8	100	50.3

Blow	Target	Btrig1	Perc	Obs. bias	Impl. bias	CVobs	Impl. CV	autocorelation
39142	0.23	61000	30	0.03	-0.07	0.24	0	coeff
Year	F	SSB	Catch	TAC	AbsIAV	Plim	Pcrash	-0.95
2012	0.219	96142	18236	18236	0	0.4	0	
2013	0.206	102585	18712	20120	22.9	0.7	0	
2014	0.23	91185	18423	19810	26.1	1.1	0	
2015	0.251	80589	17450	18764	27	2.3	0	
2016	0.258	77402	16763	18025	26.6	3.3	0	
2017	0.264	71129	15717	16899	27	5.5	0	
2018	0.259	68710	14654	15757	27.5	6.3	0	
2019	0.252	67586	13692	14723	27.8	6.6	0	
2020	0.243	67294	13027	14008	26.9	7.1	0	
2021	0.236	67589	12676	13630	27.2	7.7	0	
2022	0.229	68545	12414	13348	27.1	7.3	0	
2023	0.223	69421	12164	13079	27.5	6.4	0	
2024	0.218	70118	12087	12996	26.9	6.8	0	
2025	0.211	71289	11864	12757	27.4	6.9	0	
2026	0.206	72376	11834	12725	27	6.3	0	
2027	0.201	73213	11880	12774	26.9	5.5	0	
2028	0.197	73902	11917	12814	27.1	4.7	0.1	
2029	0.195	74514	11989	12891	26.8	4.3	0.1	
2030	0.195	74929	12094	13005	26.8	4	0.1	
2031	0.196	75222	12127	13039	26.7	4.3	0.1	
2032	0.199	75517	12410	13344	26.6	4.5	0.1	

Annex 2: Results of simulations of the proposed HCR with most plausible set of observation (Obs. CV) and implementation (Impl. CV) errors and observation (Obs. bias %) and implementation biases Impl. bias), and with stress testing. Biomass trigger (Btrig), low biomass for risk evaluation (Blow), target F (Target) and realised catch indicated in table header.

Blow	Target			Obs. bias	Impl. bias	Obs. CV	Impl. CV
39142	0.23	61000		0.03	-0.07	0.24	0
Year	F	SSB	Catch	TAC	AbsLAV	Plim	Pcrash
2012	0.219	96142	18236	18236	0	0.4	0
2013	0.206	102585	18712	20120	22.9	0.7	0
2014	0.229	90995	18768	20180	22.5	1.1	0
2015	0.244	80263	17471	18786	24.1	2.1	0
2016	0.245	77031	16620	17871	23.3	1.8	0
2017	0.245	71244	15320	16473	24.1	3.1	s
2018	0.237	69260	14306	15383	24.1	3	0
2019	0.227	68426	13455	14468	24.4	3.3	0
2020	0.223	68200	13153	14143	23.8	3.6	0
2021	0.221	68320	12950	13924	23.8	2.9	0
2022	0.221	68871	13013	13993	23.5	3.1	0
2023	0.22	69124	12981	13959	23.9	3.3	0
2024	0.219	69087	13021	14001	23.7	2	0
2025	0.213	69619	12786	13748	24.2	2.1	0
2026	0.214	70036	12924	13897	23.6	1.8	0
2027	0.213	70229	12912	13884	23.3	2	0
2028	0.214	70313	12988	13965	24.2	1.8	0
2029	0.214	70380	12995	13973	24	2.7	0
2030	0.214	70347	13033	14014	24	2.4	0
2031	0.214	70283	12992	13970	23.5	2.8	0
2032	0.216	70225	13190	14183	23.4	2.9	0

Blow	Target			Obs. bias	Impl. bias	Obs. CV	Impl. CV
39142	0.23	61000		0.03	0.1	0.24	0
Year	F	SSB	Catch	TAC	AbsIAV	Plim	Pcrash
2012	0.219	96142	18236	18236	0	0.4	0
2013	0.25	100545	22132	20120	22.9	1	0
2014	0.295	85480	22198	20180	22.5	2.7	0
2015	0.328	72317	20265	18423	24.5	4.4	0
2016	0.339	66915	18677	16979	24.2	8.1	0
2017	0.348	60514	16736	15215	25	11.1	0.1
2018	0.337	58121	15208	13826	25.3	13.4	0.1
2019	0.316	57261	13971	12701	25.7	13.4	0.1
2020	0.304	57222	13397	12180	25.1	13.2	0.2
2021	0.293	57715	13034	11849	24.7	12.6	0.4
2022	0.287	58597	13019	11835	24.5	13.1	0.4
2023	0.285	59119	13040	11855	24.9	12.1	0.4
2024	0.282	59359	13103	11911	24.6	12.2	0.4
2025	0.273	60049	12908	11734	25.2	11.7	0.4
2026	0.275	60568	13071	11884	24.2	9.3	0.5
2027	0.27	60929	13111	11919	24.2	9.8	0.6
2028	0.271	61137	13166	11969	25.2	9	0.6
2029	0.271	61391	13229	12027	24.5	9.3	0.6
2030	0.27	61509	13253	12048	24.6	10.3	0.6
2031	0.27	61622	13265	12059	24.1	9.1	0.6
2032	0.273	61546	13593	12358	24.4	9.2	0.6

Blow	Target			Obs. bias	Impl. bias	Obs. CV	Impl. CV
39142	0.23	61000		0.03	0	0.24	0
Year	F	SSB	Catch	TAC	AbsIAV	Plim	Pcrash
2012	0.219	96142	18236	18236	0	0.4	0
2013	0.224	101750	20120	20120	22.9	0.9	0
2014	0.255	88728	20180	20180	22.5	1.6	0
2015	0.275	76982	18635	18635	24.2	2.8	0
2016	0.279	72826	17503	17503	23.7	4	0
2017	0.281	66758	15945	15945	24.4	5.7	0
2018	0.272	64581	14726	14727	24.6	5.9	0.1
2019	0.258	63734	13724	13724	25	5.5	0.1
2020	0.251	63593	13325	13325	24.4	6.5	0.1
2021	0.246	63870	13063	13063	24.2	6.1	0.1
2022	0.244	64550	13103	13103	24	6.6	0.1
2023	0.243	64923	13099	13099	24.2	5.9	0.1
2024	0.241	64992	13155	13155	24	5.1	0.1
2025	0.235	65585	12922	12922	24.6	4.9	0.1
2026	0.236	66054	13071	13071	23.8	4.5	0.1
2027	0.234	66343	13066	13066	23.6	3.6	0.1
2028	0.234	66505	13138	13138	24.7	3.9	0.1
2029	0.234	66663	13157	13157	24.3	4.3	0.1
2030	0.234	66695	13218	13218	24.3	4.6	0.1
2031	0.234	66689	13191	13191	23.7	4.4	0.1
2032	0.238	66597	13449	13449	23.8	4.5	0.1

Blow	Target			Obs. bias	Impl. bias	Obs. CV	Impl. CV
39142	0.23	61000		0.03	-0.07	0.24	0.1
Year	F	SSB	Catch	TAC	AbsIAV	Plim	Pcrash
2012	0.219	96142	18236	18236	0	0.4	0
2013	0.207	102559	18746	20120	22.9	0.9	0
2014	0.231	90917	18854	20180	22.5	1.3	0
2015	0.245	80119	17528	18784	24.1	2	0
2016	0.249	76810	16718	17864	23.4	2.1	0
2017	0.249	70968	15394	16447	24.1	2.8	0
2018	0.241	68935	14380	15340	24.1	3.4	0
2019	0.231	68075	13478	14434	24.5	3.7	0
2020	0.227	67846	13161	14096	23.9	4.1	0
2021	0.224	67976	12956	13848	24	3.2	0
2022	0.222	68543	12999	13932	23.6	3.2	0
2023	0.222	68750	12998	13882	23.8	3.2	0
2024	0.22	68756	12967	13916	23.8	2.6	0
2025	0.216	69322	12779	13652	24.3	2.5	0
2026	0.215	69784	12865	13818	23.6	2.7	0
2027	0.215	70000	12939	13827	23.4	2.8	0
2028	0.216	70073	12998	13903	24.2	2.2	0
2029	0.214	70196	12921	13893	24.2	2.5	0
2030	0.217	70145	13127	13987	24	2.8	0
2031	0.215	70037	13010	13941	23.5	2.6	0
2032	0.218	70005	13163	14127	23.4	3.1	0

Blow	Target			Obs. bias	Impl. bias	Obs. CV	Impl. CV
39142	0.23	61000		0.03	-0.07	0.24	0.2
Year	F	SSB	Catch	TAC	AbsIAV	Plim	Pcrash
2012	0.219	96142	18236	18236	0	0.4	0
2013	0.211	102409	18966	20120	22.9	1	0
2014	0.238	90537	19129	20180	22.5	1.4	0
2015	0.253	79544	17751	18770	24.2	2	0
2016	0.259	76051	16925	17807	23.5	3.4	0
2017	0.261	70107	15573	16367	24.1	4.3	0
2018	0.254	67989	14529	15222	24.5	3.8	0
2019	0.244	67071	13565	14315	24.6	4.9	0.1
2020	0.238	66839	13194	13934	23.9	5.9	0.1
2021	0.234	66989	12974	13658	24.3	5.1	0.1
2022	0.23	67570	12998	13752	23.7	5.2	0.1
2023	0.231	67721	13032	13688	23.8	4.1	0.1
2024	0.227	67758	12927	13701	23.7	4.5	0.1
2025	0.224	68324	12811	13446	24.1	4.3	0.1
2026	0.221	68812	12804	13610	23.9	4.2	0.1
2027	0.221	69054	12961	13629	23.6	4.3	0.1
2028	0.224	69128	13013	13706	24.2	3.4	0.2
2029	0.219	69315	12857	13704	24.3	3.9	0.2
2030	0.224	69271	13200	13806	24	4.2	0.2
2031	0.221	69158	13026	13766	23.6	4.2	0.2
2032	0.223	69180	13109	13903	23.5	4.4	0.2

Blow	Target			Obs. bias	Impl. bias	Obs. CV	Impl. CV
39142	0.23	61000		0.03	-0.07	0.24	0
Year	F	SSB	Catch	TAC	AbsIAV	Plim	Pcrash
2012	0.219	96142	18236	18236	0	0.4	0
2013	0.206	102585	18712	20120	22.9	0.7	0
2014	0.232	90749	19183	20627	18.5	1.1	0
2015	0.247	79730	17711	19044	21.4	1.9	0
2016	0.247	76342	16610	17860	21.8	2.3	0
2017	0.254	70502	15638	16815	21.7	2.7	0
2018	0.246	68268	14583	15681	22.3	2.9	0
2019	0.238	67164	13780	14817	22.3	3.7	0
2020	0.233	66693	13436	14447	21.9	3.7	0
2021	0.232	66618	13241	14237	21.8	3.6	0
2022	0.231	66999	13242	14238	21.6	3.8	0
2023	0.231	67033	13327	14330	21.7	3.5	0
2024	0.229	66902	13228	14224	22	2.3	0
2025	0.229	67214	13228	14224	21.9	2.6	0
2026	0.227	67478	13137	14126	21.7	2.5	0
2027	0.229	67556	13256	14254	21.8	2.6	0
2028	0.227	67556	13169	14160	21.8	3.2	0
2029	0.228	67585	13261	14259	22	3.5	0
2030	0.228	67506	13236	14232	22.1	3.2	0
2031	0.226	67505	13108	14094	22.2	3.5	0
2032	0.225	67593	13229	14225	22.2	3.2	0

Blow	Target			Obs. bias	Impl. bias	Obs. CV	Impl. CV
39142	0.23	61000		0.03	-0.07	0.24	0
Year	F	SSB	Catch	TAC	AbsIAV	Plim	Pcrash
2012	0.219	96142	18236	18236	0	0.4	0
2013	0.206	102585	18712	20120	22.9	0.7	0
2014	0.231	90870	18958	20385	18.3	1.4	0
2015	0.247	80030	17565	18887	23.9	2	0
2016	0.244	76854	16356	17587	24.2	2.7	0
2017	0.25	71207	15390	16548	23.8	3.5	0
2018	0.244	69109	14483	15573	23.6	3.1	0
2019	0.234	68075	13614	14638	24.1	4.3	0
2020	0.228	67701	13239	14236	23.5	3.6	0
2021	0.225	67720	13039	14020	23.7	3.5	0
2022	0.224	68191	13015	13995	23.9	4	0
2023	0.223	68340	13061	14044	23.4	3.5	0
2024	0.22	68344	12993	13971	23.4	2.5	0
2025	0.218	68776	12985	13962	23.9	2.6	0
2026	0.214	69232	12795	13758	24	1.4	0
2027	0.217	69505	12974	13950	23.4	1.6	0
2028	0.215	69627	12951	13925	23.2	2.7	0
2029	0.217	69744	13122	14109	23.4	2.8	0
2030	0.217	69651	13083	14067	23.4	2.8	0
2031	0.216	69583	13004	13983	23.7	2.7	0
2032	0.216	69678	13054	14036	23.4	2	0

Annex 3: Results of final simulations of the proposed HCR with (Obs. CV) and implementation (Impl. CV) errors and observation (Obs. bias) and implementation biases (Impl. bias), and with stress testing. Biomass trigger (Btrig), percentage TAC constraint (Perc) low biomass for risk evaluation (Blow), target F (Target) and realised catch indicated in table header.

Blow	Target	Btrig1	Perc	Obs. bias	Impl. bias	Obs. CV	Impl. CV
26000	0.23	61000	30	0.03	0.1	0.24	0
Year	F	SSB	Catch	TAC	AbsIAV	Plim	Pcrash
2012	0.219	96142	18236	18236	0	0	0
2013	0.25	100545	22132	20120	22.9	0.1	0
2014	0.295	85480	22198	20180	22.5	0.2	0
2015	0.328	72317	20265	18423	24.5	0.5	0
2016	0.339	66915	18677	16979	24.2	1.1	0
2017	0.348	60514	16736	15215	25	1.9	0.1
2018	0.337	58121	15208	13826	25.3	2.6	0.1
2019	0.316	57261	13971	12701	25.7	3	0.1
2020	0.304	57222	13397	12180	25.1	3.8	0.2
2021	0.293	57715	13034	11849	24.7	4	0.2
2022	0.287	58597	13019	11835	24.5	3.5	0.4
2023	0.285	59119	13040	11855	24.9	3.5	0.4
2024	0.282	59359	13103	11911	24.6	3.2	0.4
2025	0.273	60049	12908	11734	25.2	2.7	0.4
2026	0.275	60568	13071	11884	24.2	2.4	0.5
2027	0.27	60929	13111	11919	24.2	2.6	0.6
2028	0.271	61137	13166	11969	25.2	2.1	0.6
2029	0.271	61391	13229	12027	24.5	1.7	0.6
2030	0.27	61509	13253	12048	24.6	1.7	0.6
2031	0.27	61622	13265	12059	24.1	2.3	0.6
2032	0.273	61546	13593	12358	24.4	2.1	0.6

Blow	Target	Btrig1	Perc	Obs. bias	Impl. bias	Obs. CV	Impl. CV
26000	0.23	61000	0	0.03	0.1	0.24	0
Year	F	SSB	Catch	TAC	AbsIAV	Plim	Pcrash
2012	0.219	96142	18236	18236	0	0	0
2013	0.307	96862	27965	25428	44.3	0.1	0.1
2014	0.315	79476	22656	20597	50.5	0.2	0.1
2015	0.312	68173	18342	16676	55.5	0.4	0.2
2016	0.315	64469	17365	15786	54.7	0.8	0.2
2017	0.306	60247	15595	14177	56.7	0.8	0.3
2018	0.293	58997	14484	13167	58.7	0.5	0.4
2019	0.297	58418	14280	12982	57.7	0.3	0.4
2020	0.305	57803	14485	13168	56.8	0.5	0.4
2021	0.301	57365	14191	12904	59.9	0.8	0.5
2022	0.311	57151	14553	13231	59.5	1	0.6
2023	0.309	56879	14188	12898	61.5	0.9	0.6
2024	0.308	56656	14050	12777	60.8	1.1	0.9
2025	0.297	56950	13813	12558	59.5	0.7	1
2026	0.301	57113	14112	12829	61.3	0.9	1
2027	0.297	57096	13875	12614	60.5	1.1	1.1
2028	0.296	57164	13935	12668	62.4	1.1	1.1
2029	0.297	57051	14036	12760	59.7	1	1.1
2030	0.293	57001	13795	12541	61.7	0.6	1.1
2031	0.288	57163	13743	12493	63	0.6	1.1
2032	0.304	57088	14214	12922	59.6	0.6	1.1

Blow	Target	Btrig1	Perc	Obs. bias	Impl. bias	Obs. CV	Impl. CV
39142	0.23	61000	30	0.03	0.1	0.24	0
Year	F	SSB	Catch	TAC	AbsIAV	Plim	Pcrash
2012	0.219	96142	18236	18236	0	0.4	0
2013	0.25	100545	22132	20120	22.9	1	0
2014	0.295	85480	22198	20180	22.5	2.7	0
2015	0.328	72317	20265	18423	24.5	4.4	0
2016	0.339	66915	18677	16979	24.2	8.1	0
2017	0.348	60514	16736	15215	25	11.1	0.1
2018	0.337	58121	15208	13826	25.3	13.4	0.1
2019	0.316	57261	13971	12701	25.7	13.4	0.1
2020	0.304	57222	13397	12180	25.1	13.2	0.2
2021	0.293	57715	13034	11849	24.7	12.6	0.4
2022	0.287	58597	13019	11835	24.5	13.1	0.4
2023	0.285	59119	13040	11855	24.9	12.1	0.4
2024	0.282	59359	13103	11911	24.6	12.2	0.4
2025	0.273	60049	12908	11734	25.2	11.7	0.4
2026	0.275	60568	13071	11884	24.2	9.3	0.5
2027	0.27	60929	13111	11919	24.2	9.8	0.6
2028	0.271	61137	13166	11969	25.2	9	0.6
2029	0.271	61391	13229	12027	24.5	9.3	0.6
2030	0.27	61509	13253	12048	24.6	10.3	0.6
2031	0.27	61622	13265	12059	24.1	9.1	0.6
2032	0.273	61546	13593	12358	24.4	9.2	0.6

Blow	Target	Btrig1	Perc	Obs. bias	Impl. bias	Obs. CV	Impl. CV
39142	0.23	61000	0	0.03	0.1	0.24	0
Year	F	SSB	Catch	TAC	AbsIAV	Plim	Pcrash
2012	0.219	96142	18236	18236	0	0.4	0
2013	0.307	96862	27965	25428	44.3	0.6	0.1
2014	0.315	79476	22656	20597	50.5	2.3	0.1
2015	0.312	68173	18342	16676	55.5	3.8	0.2
2016	0.315	64469	17365	15786	54.7	6.1	0.2
2017	0.306	60247	15595	14177	56.7	7.1	0.3
2018	0.293	58997	14484	13167	58.7	7.2	0.4
2019	0.297	58418	14280	12982	57.7	7.9	0.4
2020	0.305	57803	14485	13168	56.8	8.3	0.4
2021	0.301	57365	14191	12904	59.9	8.3	0.5
2022	0.311	57151	14553	13231	59.5	9.8	0.6
2023	0.309	56879	14188	12898	61.5	9.9	0.6
2024	0.308	56656	14050	12777	60.8	10.4	0.9
2025	0.297	56950	13813	12558	59.5	10.8	1
2026	0.301	57113	14112	12829	61.3	10.1	1
2027	0.297	57096	13875	12614	60.5	9.3	1.1
2028	0.296	57164	13935	12668	62.4	9.8	1.1
2029	0.297	57051	14036	12760	59.7	9	1.1
2030	0.293	57001	13795	12541	61.7	9.2	1.1
2031	0.288	57163	13743	12493	63	9.8	1.1
2032	0.304	57088	14214	12922	59.6	8.4	1.1

Blow	Target	Btrig1	Perc	Obs. bias	Impl. bias	Obs. CV	Impl. CV
26000	0.23	61000	0	0.1	0.2	0.34	0.1
Year	F	SSB	Catch	TAC	AbsIAV	Plim	Pcrash
2012	0.21	107634	18236	18236	0	0.2	0
2013	0.417	103567	38678	32273	59.7	0.7	0.3
2014	0.487	76865	29982	24983	63.3	2.8	1.6
2015	0.48	61229	21899	18268	72.2	4.7	3.1
2016	0.485	55137	19468	16215	71.4	6.9	4.3
2017	0.456	50019	16532	13818	73.4	7.1	5.5
2018	0.417	48444	14743	12238	76.8	7.1	6.2
2019	0.43	47625	14421	12018	75.4	8.6	7
2020	0.442	46755	14563	12119	73	9.2	8
2021	0.439	46111	14177	11761	78.5	9.8	8.7
2022	0.452	45616	14477	12086	76.9	11.5	9.5
2023	0.444	45100	13952	11610	79.4	11.9	10.2
2024	0.433	44883	13647	11374	79.3	12.3	11.5
2025	0.428	45098	13383	11138	77	11.7	12.6
2026	0.431	45164	13717	11434	80.2	12.1	13.4
2027	0.422	45020	13400	11128	78.3	11.8	14.2
2028	0.416	45059	13441	11182	81.6	11.8	14.9
2029	0.417	44949	13440	11244	77.4	12.6	15.2
2030	0.419	44910	13390	11095	80.2	10.9	15.6
2031	0.41	44996	13274	11051	81.2	11.2	16
2032	0.437	44813	13762	11451	78.9	12	16.4

Blow	Target	Btrig1	Perc	Obs. bias	Impl. bias	Obs. CV	Impl. CV
26000	0.23	61000	30	0.1	0.2	0.34	0.1
Year	F	SSB	Catch	TAC	AbsIAV	Plim	Pcrash
2012	0.21	107634	18236	18236	0	0.2	0
2013	0.276	112681	24883	20703	24.4	0.6	0
2014	0.364	92663	26502	21996	23.9	1.5	0
2015	0.453	73741	25232	20961	25.1	3.4	0.2
2016	0.543	63418	23392	19397	25.6	6.7	1
2017	0.641	52114	20380	16906	27.2	12.8	2.6
2018	0.694	46926	17597	14583	28.1	16.1	4.5
2019	0.675	44286	15206	12656	28.6	18.9	6.2
2020	0.66	42968	13653	11357	28.9	20.8	8.4
2021	0.632	42578	12668	10515	28.5	22.1	9.4
2022	0.617	42875	12088	10042	27.9	23.1	10.3
2023	0.592	43112	11584	9608	28.5	22.6	11.4
2024	0.55	43487	11323	9417	27.8	23	12
2025	0.52	44326	11002	9120	28.2	23.2	12.6
2026	0.491	45039	11037	9175	27.5	21.9	13.1
2027	0.469	45502	11138	9232	26.6	22.3	13.3
2028	0.448	45976	11039	9141	27.7	22.4	13.5
2029	0.432	46507	11063	9233	27.7	21.2	13.7
2030	0.421	46701	11280	9296	27.1	21.6	13.9
2031	0.41	47154	11170	9279	26.9	20.6	14.1
2032	0.407	47372	11445	9527	26.7	19.9	14.4

Blow	Target	Btrig1	Perc	Obs. bias	Impl. bias	Obs. CV	Impl. CV
39142	0.23	61000	0	0.1	0.2	0.34	0.1
Year	F	SSB	Catch	TAC	AbsIAV	Plim	Pcrash
2012	0.21	107634	18236	18236	0	1.9	0
2013	0.417	103567	38678	32273	59.7	3.1	0.3
2014	0.487	76865	29982	24983	63.3	8.8	1.6
2015	0.48	61229	21899	18268	72.2	17	3.1
2016	0.485	55137	19468	16215	71.4	22.6	4.3
2017	0.456	50019	16532	13818	73.4	28.1	5.5
2018	0.417	48444	14743	12238	76.8	29.8	6.2
2019	0.43	47625	14421	12018	75.4	30.5	7
2020	0.442	46755	14563	12119	73	31.3	8
2021	0.439	46111	14177	11761	78.5	33.7	8.7
2022	0.452	45616	14477	12086	76.9	33.8	9.5
2023	0.444	45100	13952	11610	79.4	36.6	10.2
2024	0.433	44883	13647	11374	79.3	37.3	11.5
2025	0.428	45098	13383	11138	77	37.5	12.6
2026	0.431	45164	13717	11434	80.2	36	13.4
2027	0.422	45020	13400	11128	78.3	36.1	14.2
2028	0.416	45059	13441	11182	81.6	37	14.9
2029	0.417	44949	13440	11244	77.4	38.2	15.2
2030	0.419	44910	13390	11095	80.2	40.1	15.6
2031	0.41	44996	13274	11051	81.2	37.4	16
2032	0.437	44813	13762	11451	78.9	38.7	16.4

Blow	Target	Btrig1	Perc	Obs. bias	Impl. bias	Obs. CV	Impl. CV
39142	0.23	61000	30	0.1	0.2	0.34	0.1
Year	F	SSB	Catch	TAC	AbsIAV	Plim	Pcrash
2012	0.21	107634	18236	18236	0	1.9	0
2013	0.276	112681	24883	20703	24.4	2.8	0
2014	0.364	92663	26502	21996	23.9	6.3	0
2015	0.453	73741	25232	20961	25.1	11.2	0.2
2016	0.543	63418	23392	19397	25.6	20.7	1
2017	0.641	52114	20380	16906	27.2	30.9	2.6
2018	0.694	46926	17597	14583	28.1	37.8	4.5
2019	0.675	44286	15206	12656	28.6	40.8	6.5
2020	0.66	42968	13653	11357	28.9	42.1	8.6
2021	0.632	42578	12668	10515	28.5	42.3	9.9
2022	0.617	42875	12088	10042	27.9	40.7	10.6
2023	0.592	43112	11584	9608	28.5	39.7	11.5
2024	0.55	43487	11323	9417	27.8	40.6	12.1
2025	0.52	44326	11002	9120	28.2	39.3	12.6
2026	0.491	45039	11037	9175	27.5	39.3	13.2
2027	0.469	45502	11138	9232	26.6	37.4	13.5
2028	0.448	45976	11039	9141	27.7	36.5	13.6
2029	0.432	46507	11063	9233	27.7	37.5	13.8
2030	0.421	46701	11280	9296	27.1	36.2	14
2031	0.41	47154	11170	9279	26.9	35.8	14.3
2032	0.407	47372	11445	9527	26.7	35.3	14.5

Blow	Target	Btrig1	Perc	Obs. bias	Impl. bias	Obs. CV	Impl. CV
26000	0.25	61000	0	0.03	0.1	0.24	0
Year	F	SSB	Catch	TAC	AbsIAV	Plim	Pcrash
2012	0.223	95511	18236	18236	0	0	0
2013	0.332	95384	29452	26779	46.2	0	0.1
2014	0.358	76406	24068	21887	52.9	0.6	0.4
2015	0.348	64980	18999	17272	57.9	1	0.5
2016	0.352	61403	17761	16158	59	1.1	0.8
2017	0.336	57377	15764	14336	62.9	1	1
2018	0.325	55835	15005	13641	63.1	1.4	1
2019	0.335	54816	14663	13330	62.1	1.4	1.1
2020	0.321	54616	14251	12955	62.5	1.1	1.1
2021	0.316	54546	13856	12597	62.7	1.4	1.2
2022	0.329	54098	14445	13138	63.8	1.5	1.4
2023	0.322	54050	13975	12707	62.2	1.4	1.5
2024	0.324	54000	14009	12736	63.7	1.4	1.6
2025	0.327	53813	13933	12668	64.2	1.9	1.9
2026	0.333	53618	14300	13000	64.1	1.6	2
2027	0.326	53283	13929	12663	65.6	1.6	2.1
2028	0.305	53646	13434	12213	66.1	1.3	2.1
2029	0.336	53467	14331	13028	62.2	1.1	2.1
2030	0.326	53093	13799	12545	63.2	1.4	2.1
2031	0.317	53619	13658	12419	64.8	1.5	2.2
2032	0.324	54183	14085	12807	65.2	1.3	2.3

Blow	Target	Btrig1	Perc	Obs. bias	Impl. bias	Obs. CV	Impl. CV
26000	0.27	61000	0	0.03	0.1	0.24	0
Year	F	SSB	Catch	TAC	AbsIAV	Plim	Pcrash
2012	0.224	94553	18236	18236	0	0	0
2013	0.356	93463	30726	27933	47.5	0	0
2014	0.375	73819	24821	22567	54	0.3	0.1
2015	0.368	61894	19483	17712	58.5	0.7	0.1
2016	0.383	58243	17731	16125	62.4	1.5	0.6
2017	0.37	54238	15923	14479	66.4	2.4	1
2018	0.367	52857	15322	13930	65.2	2.1	1.2
2019	0.346	52131	14254	12959	64.6	2.1	1.4
2020	0.356	51715	14592	13265	66.1	2.2	1.5
2021	0.359	51569	14381	13076	68.1	2.9	1.6
2022	0.362	51717	14276	12985	68.4	3.8	1.9
2023	0.359	51165	14411	13103	67.7	3.5	2.1
2024	0.353	50601	14174	12890	64.2	4	2.2
2025	0.359	50322	13949	12687	65.7	4.3	2.6
2026	0.358	50339	13780	12529	67.2	4	2.7
2027	0.338	50582	13513	12289	68.3	3.4	2.8
2028	0.348	50757	14044	12767	67.3	3	2.8
2029	0.36	50507	14122	12844	66.4	3.5	3
2030	0.358	50199	14055	12782	69.1	3.8	3.3
2031	0.361	50143	14126	12844	68.6	2.7	3.6
2032	0.361	50103	13989	12718	66.7	3	3.7

Blow	Target	Btrig1	Perc	Obs. bias	Impl. bias	Obs. CV	Impl. CV
26000	0.29	61000	0	0.03	0.1	0.24	0
Year	F	SSB	Catch	TAC	AbsIAV	Plim	Pcrash
2012	0.225	93803	18236	18236	0	0.1	0
2013	0.39	90985	32729	29753	51	0.1	0.1
2014	0.421	70280	25534	23214	53.9	0.9	0.3
2015	0.403	58406	19252	17503	62.4	1.2	0.5
2016	0.408	54360	17483	15907	66.9	2.8	0.9
2017	0.39	51102	15702	14276	68.3	2.6	1
2018	0.392	49934	15027	13663	67.2	3.5	1.1
2019	0.389	49738	14535	13217	70.6	4.4	1.5
2020	0.375	49616	14334	13034	68.6	3.5	1.6
2021	0.396	48870	14892	13540	67.2	4.3	1.8
2022	0.394	48315	14330	13028	70.5	4.5	1.9
2023	0.376	48368	13890	12631	72.1	4.1	2
2024	0.383	48162	14126	12845	71.6	4	2.4
2025	0.392	47938	14076	12799	69.4	4.9	2.6
2026	0.38	47985	13785	12540	70.4	5.1	3.1
2027	0.381	47671	13888	12625	72.1	5.7	3.2
2028	0.382	47778	13839	12588	72.9	5	3.5
2029	0.369	48218	13615	12379	70.6	4.5	3.7
2030	0.367	48235	13691	12446	68.1	4	3.7
2031	0.387	47966	14184	12898	67.8	4.8	3.9
2032	0.391	47917	14189	12902	71.1	4.4	4.2

Blow	Target	Btrig1	Perc	Obs. bias	Impl. bias	Obs. CV	Impl. CV
26000	0.23	61000	30	0.03	-0.07	0.24	0
Year	F	SSB	Catch	TAC	AbsIAV	Plim	Pcrash
2012	0.219	96142	18236	18236	0	0.4	0
2013	0.206	102585	18712	20120	22.9	0.7	0
2014	0.229	90995	18768	20180	22.5	1.1	0
2015	0.244	80263	17471	18786	24.1	2.1	0
2016	0.245	77031	16620	17871	23.3	1.8	0
2017	0.245	71244	15320	16473	24.1	3.1	0
2018	0.237	69260	14306	15383	24.1	3	0
2019	0.227	68426	13455	14468	24.4	3.3	0
2020	0.223	68200	13153	14143	23.8	3.6	0
2021	0.221	68320	12950	13924	23.8	2.9	0
2022	0.221	68871	13013	13993	23.5	3.1	0
2023	0.22	69124	12981	13959	23.9	3.3	0
2024	0.219	69087	13021	14001	23.7	2	0
2025	0.213	69619	12786	13748	24.2	2.1	0
2026	0.214	70036	12924	13897	23.6	1.8	0
2027	0.213	70229	12912	13884	23.3	2	0
2028	0.214	70313	12988	13965	24.2	1.8	0
2029	0.214	70380	12995	13973	24	2.7	0
2030	0.214	70347	13033	14014	24	2.4	0
2031	0.214	70283	12992	13970	23.5	2.8	0
2032	0.216	70225	13190	14183	23.4	2.9	0

Blow	Target	Btrig1	Perc	Obs. bias	Impl. bias	Obs. CV	Impl. CV
39000	0.23	51000	30	0.03	-0.07	0.24	0
Year	F	SSB	Catch	TAC	AbsIAV	Plim	Pcrash
2012	0.219	96142	18236	18236	0	0.4	0
2013	0.206	102585	18712	20120	22.9	0.7	0
2014	0.229	90995	18768	20180	22.5	1.1	0
2015	0.244	80263	17471	18786	24.1	2.1	0
2016	0.245	77031	16620	17871	23.3	1.8	0
2017	0.245	71244	15320	16473	24.1	3.1	0
2018	0.237	69260	14306	15383	24.1	3	0
2019	0.227	68426	13455	14468	24.4	3.3	0
2020	0.223	68200	13153	14143	23.8	3.6	0
2021	0.221	68320	12950	13924	23.8	2.9	0
2022	0.221	68871	13013	13993	23.5	3.1	0
2023	0.22	69124	12981	13959	23.9	3.3	0
2024	0.219	69087	13021	14001	23.7	2	0
2025	0.213	69619	12786	13748	24.2	2.1	0
2026	0.214	70036	12924	13897	23.6	1.8	0
2027	0.213	70229	12912	13884	23.3	2	0
2028	0.214	70313	12988	13965	24.2	1.8	0
2029	0.214	70380	12995	13973	24	2.7	0
2030	0.214	70347	13033	14014	24	2.4	0
2031	0.214	70283	12992	13970	23.5	2.8	0
2032	0.216	70225	13190	14183	23.4	2.9	0

Annex 4. Results of further simulations of the proposed HCR but with lower trigger biomasses with (Obs. CV) and implementation (Impl. CV) errors and observation (Obs. bias) and implementation biases (Impl. bias), and with stress testing.

Blow	Target	Btrig1	Perc	Obs. bias	Impl. bias	Obs. CV	Impl. CV
26000	0.23	56000	30	0.03	0.1	0.24	0
Year	F	SSB	Catch	TAC	AbsIAV	Plim	Pcrash
2012	0.225	93803	18236	18236	0	0.1	0
2013	0.257	97830	22020	20018	22.3	0.2	0
2014	0.304	83002	22073	20067	22.9	0.5	0
2015	0.334	70228	19941	18128	23.9	1.2	0
2016	0.339	65069	18112	16465	24.9	1.5	0
2017	0.343	59330	16427	14933	25	1.8	0
2018	0.335	57208	15020	13655	25.3	2	0
2019	0.326	56854	14119	12836	24.5	2.6	0
2020	0.313	57027	13466	12242	24.8	3.2	0
2021	0.305	57356	13346	12133	24.5	3.4	0
2022	0.298	57684	13285	12078	25.4	3.3	0.2
2023	0.288	58193	13118	11925	24.4	3.1	0.3
2024	0.28	58453	13060	11873	24.2	2.1	0.3
2025	0.278	58723	13065	11877	23.8	2.2	0.4
2026	0.277	59050	13107	11916	24.2	2	0.5
2027	0.279	58978	13163	11966	24.4	2.4	0.5
2028	0.278	59402	13156	11960	24.5	2.1	0.5
2029	0.276	59873	13215	12013	24.4	2.2	0.5
2030	0.275	59867	13325	12114	23.9	1.9	0.5
2031	0.277	59834	13429	12208	23.9	1.8	0.5
2032	0.276	60177	13427	12206	24.2	1.8	0.5

Blow	Target	Btrig1	Perc	Obs. bias	Impl. bias	Obs. CV	Impl. CV
26000	0.23	51000	30	0.03	0.1	0.24	0
Year	F	SSB	Catch	TAC	AbsIAV	Plim	Pcrash
2012	0.224	94553	18236	18236	0	0	0
2013	0.253	99022	21930	19936	22.5	0	0
2014	0.294	84369	21837	19852	23	0.3	0
2015	0.326	71626	20222	18384	24.1	0.5	0
2016	0.335	66985	18604	16912	24.5	0.7	0
2017	0.35	60310	16830	15300	24.9	1.8	0.1
2018	0.35	57912	15439	14037	24.7	2.1	0.3
2019	0.335	56658	14288	12989	24.3	2.6	0.4
2020	0.324	56346	13729	12481	25	3.9	0.4
2021	0.316	56639	13438	12216	24.2	4.2	0.5
2022	0.303	57446	13149	11954	24.5	4	0.5
2023	0.301	57392	13160	11964	23.4	4.1	0.7
2024	0.297	57416	13131	11938	23.9	3.7	0.7
2025	0.292	57678	13030	11845	24.4	2.7	0.7
2026	0.289	57863	13047	11861	24.7	3.4	0.7
2027	0.283	58164	12874	11703	24.4	3.1	0.8
2028	0.28	58751	12976	11796	24.2	3.2	0.8
2029	0.28	58942	13216	12014	23.7	3	0.8
2030	0.283	58923	13343	12130	23.6	2.4	0.8
2031	0.285	58989	13448	12225	24	2.5	0.8
2032	0.286	58876	13524	12295	23.4	2.1	0.8

Blow	Target	Btrig1	Perc	Obs. bias	Impl. bias	Obs. CV	Impl. CV
26000	0.23	46000	30	0.03	0.1	0.24	0
Year	F	SSB	Catch	TAC	AbsIAV	Plim	Pcrash
2012	0.223	95511	18236	18236	0	0	0
2013	0.251	100146	21973	19975	22.4	0	0
2014	0.299	84891	22245	20223	22.9	0.2	0
2015	0.332	72021	20434	18576	24.4	0.5	0
2016	0.34	67113	18830	17118	23.9	1.4	0
2017	0.347	60639	16963	15420	24.9	1.4	0
2018	0.339	57898	15477	14070	24.7	2.3	0
2019	0.327	56572	14493	13176	24.3	2.7	0.1
2020	0.312	56311	13807	12552	24.1	2.6	0.1
2021	0.302	56397	13338	12126	24.4	2.9	0.2
2022	0.299	56441	13327	12116	23.2	3.1	0.2
2023	0.297	56862	13229	12027	23.8	2.8	0.2
2024	0.291	57321	13129	11935	23.8	2.9	0.2
2025	0.289	57558	13046	11861	23.5	3.1	0.3
2026	0.291	57731	13260	12055	23.4	3.2	0.3
2027	0.29	57757	13267	12061	24	3.2	0.3
2028	0.285	57939	13142	11947	24	2.9	0.3
2029	0.287	58019	13348	12135	22.9	2.4	0.3
2030	0.285	57744	13291	12083	23.7	1.8	0.3
2031	0.286	58078	13312	12101	23.6	1.8	0.3
2032	0.289	58553	13506	12279	23	1.7	0.4

Annex 5 -Technical Minutes

Generic comments (appropriateness of methods used, has the full range of options been looked at etc):

- Maurice The draft expert report was presented, which was drafted in a similar manner to the ICES Advice standard template. Overall, the RG/ADG Members were satisfied that the experts' simulations had answered the request. There was some discussion on how precautionary (e.g. are we erring too much on the side of caution) the choice of B_{lim} is given the stock-recruitment relationships presented in Figure 5.4.16.3 (ICES 2012) and the model fit presented in the draft report. In addition, further simulations were requested by the RG/ADG; these were made available and made substantial contributions to the advice as drafted.

Technical comments

- The RG/ADG had an in depth discussion of the method used by the experts in examining stock-recruitment dynamics. The suggested new B_{lim} was set to 39 000 t based on a segmented regression analysis. According to the ICES guidelines on reference points (e.g. ICES CM 2003/ACFM:15) B_{lim} can be estimated from a segmented regression if the S/R has a clear change point (slope line and plateau) signal. Celtic Sea herring has a clear plateau but no slope line (recruitment seems independent of SSB, even for low SSB). According to the ICES guidelines, B_{lim} can be set to B_{loss} in such case. The present ICES value of B_{lim} (26 000 t) has been defined from B_{loss} and the RG/ADG concluded to maintain this value for evaluating risk to B_{lim} . The stock recruitment relationship used to produce scenario recruitment is based on a segmented regression with estimated changepoint at 39 000 t. Such an approach might underestimate recruitment at low SSB, but it was decided to accept the presented simulations as they were as basis for advice.
- This would be ADG I think - To further understand this issue, the experts provided the RG/ADG with alternatives
 - The RG/ADG provided (see table below) the experts with a list of plausible biases and uncertainties to be checked against 26 000 t, and the experts also placed stresses beyond these to show what could happen.

	Plausible (%)	Values used for testing (%)
Observed bias	+0.03	+0.1
Observed error	0.24	0.34
Implementation bias	0.0	-0.10
Implementation error	0.10	0.20

This was included in the draft advice.

Conclusions

- The MSE evaluation report was made available to the RG/ADG at the beginning of the RG/ADG. This was too late. Expert reports should be made available further in advance of the RG/ADG; however, due to an efficient response from the expert, the RG/ADG felt that their comments were taken

into account in an adequate way and that the scientific basis for advice was sufficient.

- The RG/ADG agrees with the approach taken by the experts; however, with the change that the risk to B_{lim} should be evaluated from the presently used B_{lim} value at 26 000 t
- The RG/ADG requests that the experts create summary tables (similar to those found in the LTMP Advice for NS herring) for use in the Advice, and to define the stresses that were used for testing and why in a short paragraph.
- It is also requested that the Expert Group Chair work with the Secretariat to produce a final report from the draft Expert Group document. The final version of this document was made available to the RG/ADG the morning of the second day of the RG/ADG.