Evaluation of the LTMP for Celtic Sea herring in the light of the 2015 benchmark

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Introduction

A long term management plan (LTMP) was proposed by the Pelagic AC in 2012 and has been used by managers since 2013 (Annex 1). The harvest control rule (HCR) in plan was evaluated by ICES in 2012 and found to be consistent with the precautionary approach. It was also found to deliver long term sustainable yield, at the expense of maximising yield in any one year (ICES ADGCSHER, 2012). The proposed target F is 0.23 and the trigger biomass point is 61 000 t.

This plan has been followed by the Council of the European Union in each year since 2013 for TAC setting. The plan has not formed the basis of the ICES advice for 2013, 2014 or 2015, however. This is because of a legal problem between the institutions of the European Union. The Lisbon Treaty (entered into force 2009) requires so called "co-decision" between the three political institutions of the Union. This formality has not been achieved, to date. Thus the LTMP has been the *de facto* rather than the *de jure* TAC setting mechanism for the stock.

The plan was re-evaluated, by HAWG 2014, in the light of the new benchmark of the stock in that year. It was judged to still be consistent with the precautionary approach, based on simulations conducted (ICES HAWG 2014). A further benchmark was conducted in 2015. The assessment conducted at the Benchmark in February 2015 (ICES WKWEST, 2015) was found to be invalid, due to erroneous natural mortality estimates having been provided by DTU-AQUA. An updated assessment was conducted by HAWG 2015, and based on this an evaluation of the LTMP was conducted. This evaluation followed the simulation approach taken to frame reference points in ICES WKWEST 2015. This document presents an updated evaluation, following the procedures of WKWEST 2015, HAWG 2014 and ADGCSHER 2012, but using the corrected M values, and based on the corrected assessment. This evaluation requires peer review. The ICES Secretariat has suggested that this review be conducted by WKWEST (Morgado pers. comm.).

Materials and methods

The procedure follows exactly the approach taken by HAWG 2014. Simulations were performed using HCS 10-3 (Skagen, 2010). This stochastic projection programme allows for various sources of precision and bias to be considered, including retrospective bias and implementation error. The final stock recruitment relationship from ICES WKWEST (2015 in prep.) was used along with the final population numbers from 2013. Risk profiles follow ICES guidelines (Risk <5% to B_{lim} in any simulation year, "ICES Risk 2"). This is the most precautionary risk tolerance considered by ICES.

The software used was HCS 10-3 (Skagen, 2010; 2013). Errors and biases were as per the final configuration from the long term management plan (LTMP) evaluation of 2012 (ICES AGDCSHER, 2012), with updated inputs from the benchmark ASAP assessment conducted in 2015. Inputs to these simulations are presented in Table 1. A number of scenarios were tested as follows:

1) Base case; LTMP with 10% implementation bias (additional unaccounted mortality).

2) Current LTMP HCR across a range of retrospective down-ward revisions of SSB

3) As in 2, above but assuming 10% implementation bias.

4) As in 2 above, but considering instead differing interannual TAC constraints

5) As 2 adjusted to have a higher target F.

6) A sensitivity analysis to determine the degree to which the LTMP is robust to assessment error

The stock recruitment used (Figure 1) is based on the procedure and data used by ICES WKWEST (2015), with one difference. The assessment was re-run with the new corrected natural mortality schedules, which are those used by WKPELA (2014). Following the procedure of WKWEST (2015) the breakpoint is fixed at B_{lim}, as estimated by HAWG (2015), based on the corrected M values in a revised assessment using ASAP.

Results

The LTMP HCR is robust to the new benchmarked assessment. Table 2 shows the results of the base case run. This simulation shows that the current HCR has low risk to $B_{lim.}$ This simulation includes, for precautionary purposes, a 10% implementation bias, following the procedure agreed at ICES ADGCSHER 2012.

Further stress-testing of the HCR was conducted. Results of tests of the current LTMP HCR show that the plan is robust to downward revisions of stock size up to 16% on average across the entire simulation period of 20 years (Table 3). Downward revisions of greater than that are associated with risks of more than 5% to B_{lim}. When implementation bias (unaccounted mortality) is included as an additional 10%, the HCR is not robust to retrospective downward revisions of greater than 3% across the 20 year simulation period (Table 4).

Reducing inter-annual TAC constraints below 30% were associated with unacceptable risk, assuming 10% implementation bias (Table 5). Evaluations were conducted to evaluate the effect of changing the F target. If retrospective bias was on average 24% across the time period, managers should consider reducing the F target to be redued from 0.18, to maintain low risk, whilst maintaining the $B_{trigger}$ and inter-annual TAC constraint (Table 6)..

A final sensitivity run was conducted to investigate what level of assessment uncertainty (CV) would lead the LTMP to have high risk. Results (Table 7) show that any CV greater than 0.36 is high risk. The corrected assessment conducted in HAWG (2015) had a CV of 33%. This slight decline in precision may be due to the exclusion of the 2014 acoustic values, based on a recommendation from ICES WGIPS (2015) that the survey was unreliable. The result of this sensitivity analysis shows that the current assessment is not detrimental to the performance of the LTMP.

Discussion and conclusions

The results of this simulation show that the plan is still precautionary and still delivers stable yield over time, at the expense of maximising yield in any year. The overall findings of this study are consistent with the findings of the previous evaluations (ADGCSHER, 2012; HAWG, 2014). It is recommended that the plan be followed for TAC setting in 2016 and subsequent years.

The precautionary thresholds assumed here are very strict. The most stringent ICES Risk profile (Risk 2) was used. This means that if the risk to B_{lim} is greater than 5% in any year, the scenario tested is deemed to have failed. In addition, a 10% implementation bias is assumed. This LTMP was the first in ICES to have implementation bias included in its evaluation (ICES ADGCSHER, 2012), and this continues with the current work.

The HCR was further stress-tested to determine what set of conditions would lead to it failing to deliver low risk to B_{lim}. The most important consideration was observation bias, or retrospective revision. Negative retrospective revisions of SSB may lead to poor HCR performance. The results of this work

show that the LTMP can tolerate an annual downward revision of 16%, or 3% if implementation bias of 10% is also considered. For the LTMP to be at risk of failure, downward revision would have to be greater than 16% every year over the future 20 years. To date there has not been a consistent downward revision from year to year, and therefore there is no need to alter the HCR.

Negative revisions of SSB were a feature of the 2014 assessment. However the 2015 assessment is characterised by a positive revision of SSB. The simulation work shows the sensitivity of the HCR to retrospective bias. Recent history (Figure 2 of the assessment suggests that there is no need to alter the HCR, unless downward revisions become a persistent feature of the assessment. All recent assessment of the stock, considered together (Figure 3) show a relatively balanced pattern with both positive and negative revisions. It is worth noting that the new ASAP assessment is characterised by a much lower retrospective pattern than the previous SAM model (ICES WKWEST, 2015). Retrospective revision is not normally considered in MSE work in ICES. The work conducted here is for illustrative purposes. If downward revision becomes a permanent feature of the assessment in the future, managers may consider HCR alteration. The current study could serve as an illustration of how such alterations could be made.

In conclusion, the current LTMP, as used by managers in TAC setting in 2013-2015, is still precautionary and can continue to be used, should managers wish to continue using it.

References

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Skagen, 2010. HCS A stochastic projection package. Skagen Fisheries Consultant. Bergen. 44 pp.

Table 1. Input data as used in the stochastic projections.

Input	Notes
Stock recruitment relationship	Segmented regression, ICES WKWEST, 2015, updated with corected natural mortality. Fitted using Julios (2001) method which was used to estimate plateau recruitment. Bchangepoint set as Blim.
Observation error (CV)	30%, WKWEST 2015
Observation bias	varying
Implememntation CV	0
Implementation bias	as per ICES ADGCSHER (2012), 10% assumed as base case
Initial numbers	Benchmark assessment WKWEST 2015, with correct natural mortality schedules
Weights at age	Benchmark assessment WKWEST 2015
Selection pattern	Benchmark assessment WKWEST 2015
Blim	B_{loss} 33,000 t following ICES WKWEST 2015, updated with corrected natural mortality (ICES WKPELA 20145)
Natural mortality	Corrected values, as per WKPELA, 2014

Table 2. Results of stochastic simulations of the current LTMP HCR, with 10% implementation bias, showing trajectories of F SSB, Catch, TAC and interannual TAV variation (AbsIAV), percentage risk of SSB<Blim indicated (Plim) and risk of there not being enough fish in the population to deliver a catch (Pcrash).

Year	F	SSB	Catch	TAC	Abs IAV	Plim	Pcrash
2014	0.186	151585	19574	19574	0	0	0
2015	0.224	144496	23905	21732	23.4	0.2	0
2016	0.261	125371	25659	23327	23.3	0.2	0
2017	0.307	101702	24943	22676	24.3	0.3	0
2018	0.337	86297	22681	20619	25	0.7	0
2019	0.356	75562	19979	18163	26.5	2.2	0
2020	0.354	69526	17771	16155	26.9	2.2	0.1
2021	0.341	67547	16237	14761	25.6	2.9	0.1
2022	0.328	65521	14844	13494	26.5	3.9	0.1
2023	0.308	66092	14380	13072	25.6	4.2	0.2
2024	0.294	67149	14066	12787	25.4	3.2	0.2
2025	0.285	67877	14060	12782	24.8	2.6	0.2
2026	0.281	68695	14052	12774	25.3	2	0.2
2027	0.276	69093	14106	12823	24.8	2.1	0.2
2028	0.275	69936	14120	12836	25.5	2.3	0.2
2029	0.274	70373	14142	12857	25.2	2.2	0.2
2030	0.273	70347	14178	12889	25.3	1.9	0.2
2031	0.27	70512	14180	12891	24.5	2	0.2
2032	0.271	70360	14250	12955	24.8	1.8	0.2
2033	0.276	69910	14417	13106	24.9	2	0.2
2034	0.276	69512	14402	13093	24.7	1.8	0.2

Table 3. Results of stochastic simulations of the current LTMP HCR, showing the highest observation bias (16% average downward retrospective revision of SSB over time) consistent with low risk to B_{lim}, showing trajectories of F SSB, Catch, TAC and inter-annual TAV variation (AbsIAV), percentage risk of SSB<Blim indicated (P_{lim}) and risk of there not being enough fish in the population to deliver a catch (P_{crash}). No implementation bias is assumed in this simulation.

Year	F	SSB	Catch	TAC	Abs IAV	Plim	Pcrash
2014	0.157	180727	19574	19574	0	0	0
2015	0.191	173377	23824	23824	24	0	0
2016	0.238	148705	27216	27216	23.2	0.1	0
2017	0.302	117092	27924	27924	23.7	0.4	0
2018	0.349	95493	25822	25822	24.8	0.9	0
2019	0.392	79203	22767	22767	25.9	2.1	0
2020	0.405	69786	19898	19898	26.8	3.6	0
2021	0.395	67110	18065	18065	25.5	3.6	0
2022	0.379	63842	16428	16428	25.7	4.4	0
2023	0.358	63609	15545	15545	25.9	4.9	0
2024	0.341	64523	15083	15083	25.2	4.6	0
2025	0.318	65804	14685	14685	25	4.9	0
2026	0.311	66102	14760	14760	24.8	3.9	0
2027	0.304	65931	14574	14574	24.6	3.4	0
2028	0.309	65931	14879	14880	24.9	3.6	0.1
2029	0.305	65827	14714	14714	24.6	3.5	0.1
2030	0.305	66051	14447	14447	24.5	3.7	0.1
2031	0.305	66122	14636	14636	24.6	3.3	0.1
2032	0.307	65855	14632	14632	24.5	3.6	0.1
2033	0.305	65545	14506	14506	24.7	3.4	0.1
2034	0.302	66161	14387	14387	24.6	2.8	0.1

Table 4. Results of stochastic simulations of the current LTMP HCR, showing the highest observation bias (3% downward retrospective revision of SSB over time) consistent with low risk to B_{lim} whilst also assuming 10% implementation bias. Trajectories of F SSB, Catch, TAC and interannual TAV variation (AbsIAV) are shown. Percentage risk of SSB<Blim indicated (P_{lim}) and risk of there not being enough fish in the population to deliver a catch (P_{crash}) are also indicated.

Year	F	SSB	Catch	TAC	Abs IAV	Plim	Pcrash
2014	0.179	156428	19574	19574	0	0.2	0
2015	0.227	147144	24678	22435	23.9	0.4	0
2016	0.269	126125	26649	24226	23.3	0.5	0
2017	0.317	100920	25760	23418	24	0.4	0
2018	0.349	84852	23149	21045	25.5	0.6	0
2019	0.378	73702	20601	18729	26.2	1.3	0.1
2020	0.38	67876	18240	16583	26.5	2.3	0.2
2021	0.364	66317	16659	15148	26.3	3.7	0.3
2022	0.352	64824	15488	14081	25.8	3.6	0.4
2023	0.328	64844	14845	13496	25.5	4.4	0.5
2024	0.313	64975	14357	13051	25.2	4.3	0.5
2025	0.3	65431	14163	12875	24.6	3.7	0.5
2026	0.293	66124	13978	12707	24.9	3.7	0.5
2027	0.293	66878	14058	12780	25.2	4.6	0.5
2028	0.29	67456	14090	12809	25.1	3.2	0.5
2029	0.281	68213	14043	12766	24.2	2.9	0.5
2030	0.278	68803	14093	12812	24.8	2.2	0.6
2031	0.28	69265	14396	13087	24.6	1.5	0.7
2032	0.279	69097	14460	13145	24.9	1.9	0.7
2033	0.278	69205	14405	13095	25.1	1.6	0.7
2034	0.275	69071	14275	12977	24.8	1.4	0.7

Table 5. Results of stochastic simulations of the current LTMP HCR, showing the lowest interannual TAC variation constraint consistent with low risk to B_{lim} (30% IAV) whilst also assuming 10% implementation bias. Trajectories of F SSB, Catch, TAC and interannual TAV variation (AbsIAV) are shown. Percentage risk of SSB<Blim indicated (P_{lim}) and risk of there not being enough fish in the population to deliver a catch (P_{crash}) are also indicated.

Year	F	SSB	Catch	TAC	Abs IAV	P_{lim}	Pcrash
2014	0.186	152081	19574	19574	0	0.1	0
2015	0.227	144175	24279	22072	23.8	0.2	0
2016	0.264	123754	25777	23433	23.3	0.2	0
2017	0.315	99981	24862	22601	24.6	0.3	0
2018	0.345	84830	22832	20756	25	1	0
2019	0.373	74145	20135	18305	26.5	1.8	0
2020	0.379	68184	17782	16173	25.9	3.2	0.5
2021	0.363	66632	16274	14795	25.8	3.9	0.5
2022	0.343	64658	14975	13618	26.2	4	0.7
2023	0.32	65472	14242	12948	25.4	4.1	0.8
2024	0.294	67042	13791	12538	25.6	3.3	0.9
2025	0.289	67527	13907	12643	25	3.2	1
2026	0.284	67876	13828	12571	25.2	2.8	1
2027	0.278	68877	13698	12452	25.4	3	1
2028	0.275	69350	13941	12674	24.6	2.2	1
2029	0.273	69557	14014	12740	25.1	1.9	1
2030	0.272	70010	13970	12700	25.1	1.9	1
2031	0.274	69914	14137	12852	24.6	1.9	1
2032	0.276	70157	14211	12919	24.8	2.2	1
2033	0.27	70449	14179	12890	24.3	2	1.1
2034	0.268	70680	14287	12988	25	2.1	1.1
2034	0.268	70680	14287	12988	25	2.1	1.1

Table 6. Results of stochastic simulations of the a modified HCR, showing the highest target F consistent with low risk to B_{lim}, whilst maintaining the other parameters of the current HCR, and also assuming 10% implementation bias, and 24% negative retrospective revision across the period. Trajectories of F, SSB, Catch, TAC and interannual TAV variation (AbsIAV) are shown. Percentage risk of SSB<Blim indicated (P_{lim}) and risk of there not being enough fish in the population to deliver a catch (P_{crash}) are also indicated

Year	F	SSB	Catch	TAC	Abs IAV	Plim	Pcrash
2014	0.147	192155	19574	19574	0	0	0
2015	0.191	183266	25709	23372	23.9	0.1	0
2016	0.241	154522	29042	26402	22.6	0	0
2017	0.3	120355	28608	26007	23.8	0.1	0
2018	0.346	97880	26310	23918	24.6	0.6	0
2019	0.387	81287	23150	21046	26.2	1.5	0.1
2020	0.406	71322	20062	18241	26.1	3.6	0.5
2021	0.391	67822	17834	16213	26.1	4	0.6
2022	0.381	64372	16002	14548	25.4	4.2	0.9
2023	0.361	64023	15251	13867	24.8	4.6	1.4
2024	0.336	64198	14652	13320	24.6	4.2	1.5
2025	0.322	65119	14399	13090	24.6	3.8	1.5
2026	0.307	66253	14345	13041	24.2	3.4	1.5
2027	0.303	66578	14523	13203	24.6	4.2	1.5
2028	0.298	66684	14449	13135	24.5	4.2	1.5
2029	0.292	67327	14235	12940	24.3	3.7	1.5
2030	0.284	67772	14235	12941	24.8	2.9	1.5
2031	0.284	67890	14366	13060	24.3	3	1.5
2032	0.287	67500	14476	13160	24.2	2.9	1.5
2033	0.289	67494	14458	13144	24.2	2.8	1.5
2034	0.284	67818	14381	13073	24.8	3.1	1.5

Table 7. Results of stochastic simulations of a sensitivity analysis for assessment CV on the current LTMP HCR, showing the highest assessment CV (CV=0.36) consistent with low risk to B_{lim}, and also assuming 10% implementation bias. Trajectories of F SSB, Catch, TAC and inter-annual TAV variation (Abs IAV) are shown. Percentage risk of SSB<Blim indicated (P_{lim}) and risk of there not being enough fish in the population to deliver a catch (P_{crash}).

Year	F	SSB	Catch	TAC	ABS IAV	Plim	Pcrash
2014	0.193	156661	19574	19574	0	0.3	0
2015	0.235	149320	23795	21632	24.6	0.7	0.1
2016	0.269	128824	25701	23364	24.3	0.5	0.1
2017	0.316	104215	24861	22601	24.6	1.1	0.1
2018	0.351	88511	22833	20760	26.2	2.6	0.3
2019	0.375	76623	20172	18338	26.8	3.2	0.3
2020	0.384	69478	18096	16452	27.3	4.1	0.6
2021	0.361	67448	16222	14748	27	4.7	0.7
2022	0.346	65007	15067	13698	26.5	4.5	0.7
2023	0.322	65342	14237	12945	26.4	4.6	0.9
2024	0.301	66253	13833	12576	26.4	4.2	0.9
2025	0.29	67344	13713	12467	25.9	3.9	1.1
2026	0.278	68505	13668	12425	25	3	1.1
2027	0.273	69175	13675	12432	25.4	3.8	1.1
2028	0.275	69779	13922	12656	25.9	3.2	1.1
2029	0.274	70207	14031	12756	25.4	2.2	1.1
2030	0.275	70222	14101	12819	25.7	2.9	1.1
2031	0.281	69805	14122	12838	26.1	2.7	1.1
2032	0.283	69297	14143	12858	25.4	2.7	1.1
2033	0.286	68712	14136	12852	25.2	3.6	1.2
2034	0.283	68397	13997	12725	26	3.4	1.2
2034	0.283	68397	13997	12725	26	3.4	1.2

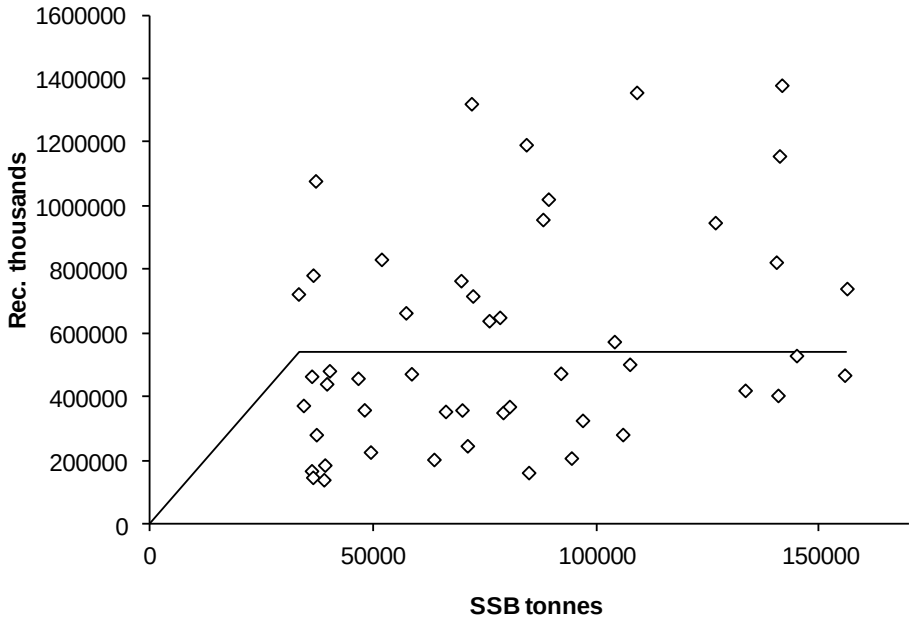

Figure 1. Herring in the Celtic Sea. Stock recruitment relationship following benchmark assessment procedure, but with corrected natural mortality schedules. The plateau recruitment was estimated as 541 287 millions, and the changepoint (set at Blim) is 33 210 t.

year	2015/2014	2015/2013	2015/2012	2014/2013	2014/2012	2014/2011	2013/2012	2013/2011	2013/2010
2003	1.73	1.18	1.27	0.68	0.73	0.62	1.08	0.91	0.91
2004	1.63	1.35	1.50	0.82	0.92	0.72	1.12	0.88	0.88
2005	2.18	1.47	1.71	0.67	0.78	0.57	1.16	0.84	0.86
2006	2.29	1.51	1.79	0.66	0.78	0.55	1.19	0.84	0.87
2007	2.01	1.52	1.84	0.75	0.92	0.62	1.21	0.82	0.88
2008	1.81	1.41	1.74	0.78	0.96	0.63	1.24	0.81	0.89
2009	1.78	1.24	1.58	0.70	0.89	0.58	1.27	0.83	1.18
2010	1.71	1.12	1.50	0.66	0.88	0.65	1.35	0.99	
2011	1.74	0.92	1.70	0.53	0.97		1.84		
2012	1.65	0.88		0.53					
2013	1.54								

Figure 2. Pictogram showing positive (green background, black text) and negative (red background, white text) revisions of SSB by assessments conducted in 2015 (left panel), 2014 (middle panel) and 2013 (right panel).

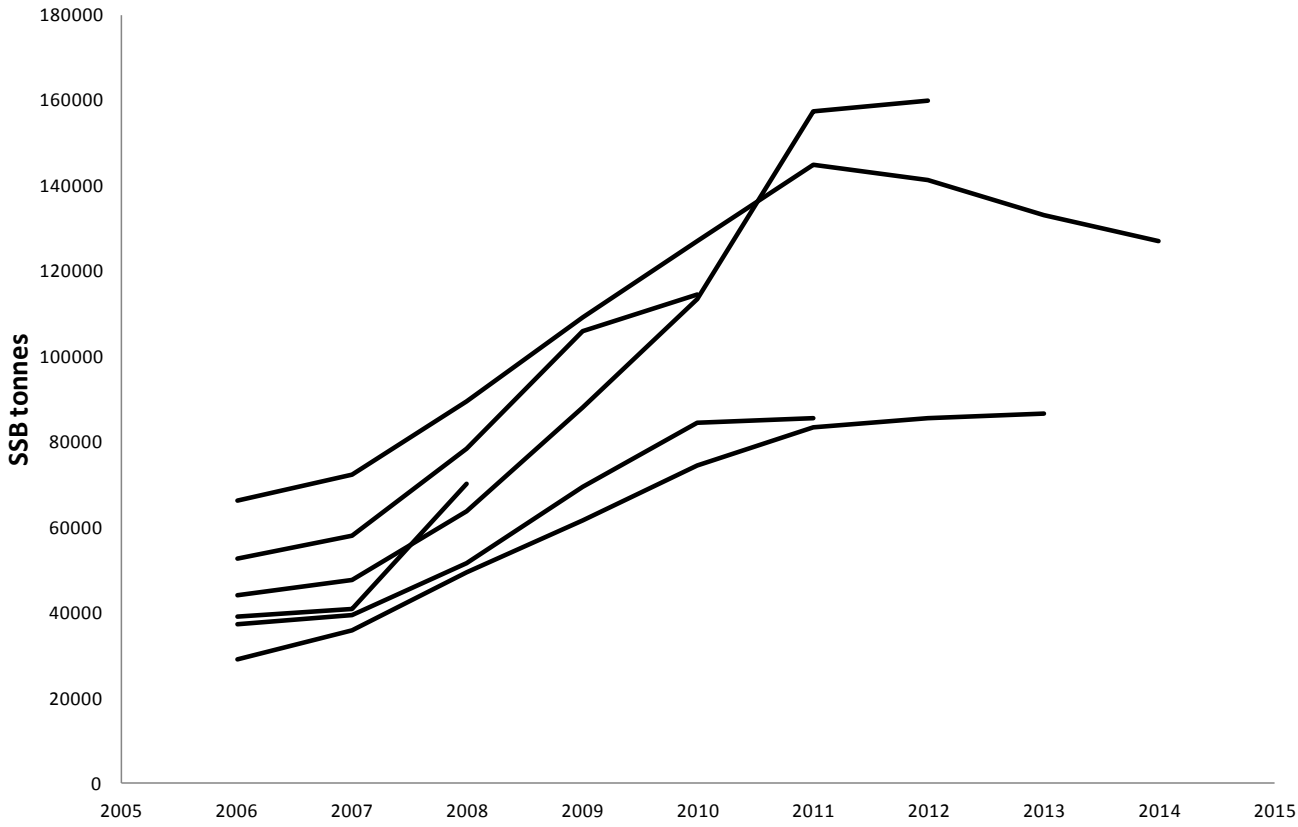

Figure 3. Historical retrospective pattern for SSB from all accepted assessments of this stock in recent years.

Annex1 : Long-term management plan for herring in the Celtic Sea and Division VIIj

1. *Every effort shall be made to maintain a minimum level of Spawning Stock Biomass (SSB) greater than 41,000 t, the level below which recruitment becomes impaired.*
2. *Where the SSB, in the year for which the TAC is to be fixed, is estimated to be above 61,000 t ($B_{trigger}$) the TAC will be set consistent with a fishing morality, for appropriate age groups, of 0.23 (F_{target}).*
3. *Where the SSB is estimated to be below 61,000 tonnes, the TAC will be set consistent with a fishing mortality of:*

   *SSB * 0.23 / 61,000*

4. *Where the rules in paragraphs 2 and 3 would lead to a TAC which deviates by more than 30 % from the TAC of the preceding year, the TAC will be fixed such that it is not more than 30 % greater or 30 % less than the TAC of the preceding year.*
5. *Where the SSB is estimated to be below 41,000 tonnes, Subdivision VIIaS will be closed until the SSB has recovered to above 41,000 tonnes.*
6. *Where the SSB is estimated to be below 41,000 tonnes, and Sub-Division VIIaS is closed, a small-scale sentinel fishery will be permitted in the closed area. This fishery will be confined to vessels, of no more than 50 feet in registered length. A maximum catch limitation of 8% of the Irish quota will be exclusively allocated to this sentinel fishery.*
7. *Notwithstanding paragraphs 2, 3 and 4, if the SSB is estimated to be at or below the level consistent with recruitment impairment (41,000 t), then the TAC will be set at a lower level than that provided for in those paragraphs.*
8. *No vessels participating in the fishery, if requested, will refuse to take on-board any observer for the purposes of improving the knowledge on the state of the stock. All vessels will, upon request, provide samples of catches for scientific analyses.*
9. *Every three years from the date of entry into force of this Regulation, the Commission will request ICES and STECF to review and evaluate the plan.*
10. *This arrangement enters into force on 1st January, 2012.*